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CAPISIC BROOK WATERSHED

FLOOD PLAIN MANAGEMENT STUDY

Technical Report Summary

OCTOBER 1995

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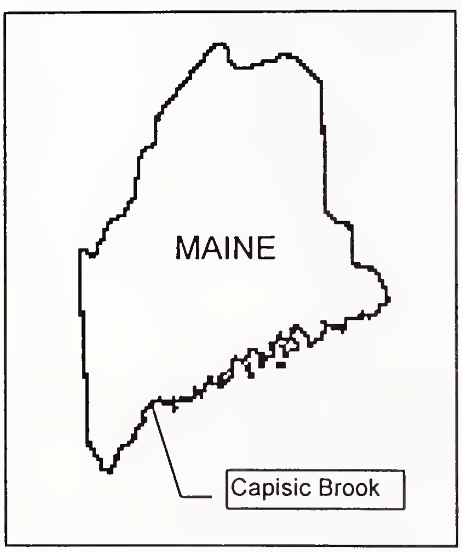
INTRODUCTION

The Natural Resources Conservation Service (NRCS), formerly the Soil Conservation Service (SCS), conducted this study in response to a request by the City of Portland to the Cumberland County Soil and Water Conservation District. The City submitted a formal application for the study to the Maine Soil and Water Conservation Commission, which establishes study priorities throughout Maine under a Joint Coordination Agreement with NRCS. NRCS assistance to units of government for flood plain management studies is authorized by Section 6 of Public Law 83-566, the Watershed Protection and Flood Prevention Act of 1954, as amended. NRCS and other federal agency involvement is also guided by Executive Order 11988, Flood Plain Management; and by "A Unified National Program for Floodplain Management", Federal Interagency Floodplain Management Task Force, 1994.



This Flood Plain Management Study was conducted in support of the *Capisic Brook Greenbelt/Stormwater Abatement Study*. This report summarizes the studies conducted by the NRCS within the Capisic Brook Watershed. The focus of NRCS activities was confined to evaluation of existing flood hazards and flood damage, and hydraulic and hydrologic modeling support for the Stormwater Abatement Study. The report presents information related to the flood hazards that currently exist and potential actions to lessen the hazards, with emphasis on the technical aspects of how the study was carried out.

The technical information provided in this report, and in the separate Appendices, will be useful to the City of Portland in identifying flood plain areas, properties subject to flooding, and potential remedies to existing flood problems. The computer data files and Geographic Information System (GIS) data layers will be useful in improving and managing the resources of the watershed.

STUDY AREA

The study area encompasses Capisic Brook and its two main tributaries, the West Branch and the East Branch, above Capisic Pond Dam (See Figure 1). The drainage area is 2.63 square miles (1683.4 acres). The watershed lies primarily in the western part of the City of Portland, with a small portion in the City of Westbrook in the vicinity of Exit 8 of the Maine Turnpike (I-95). Capisic Brook is a tributary of the Fore River which empties into Casco Bay. The Fore River and its tributaries are designated as hydrologic unit code 01060001-110.

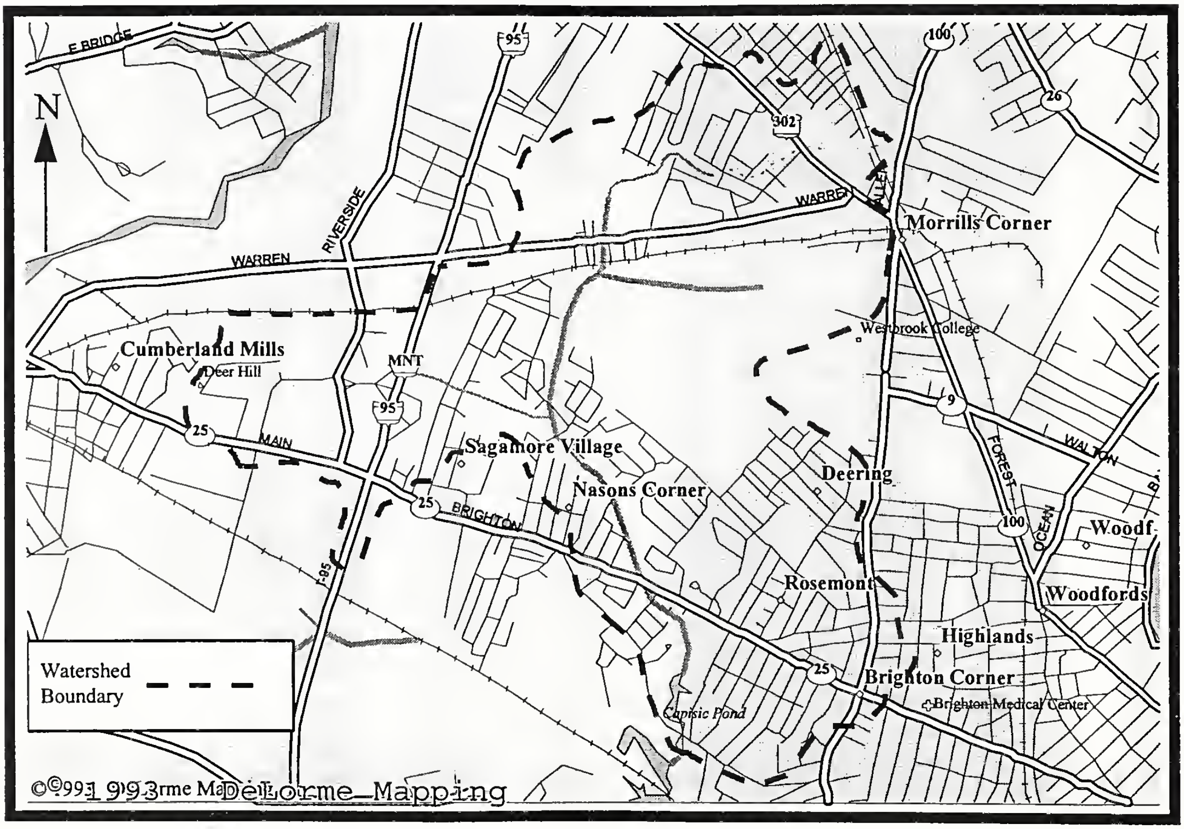


Figure 1 - Capisic Brook Watershed Map

Capisic Brook rises northeast of Forest Avenue and flows southwest to Warren Avenue, and then generally south to the Fore River. Capisic Pond Dam was selected as the downstream limit of the study area for hydraulic purposes. Tributaries consist of the East and West Branches of Capisic Brook. The East Branch headwaters are in the vicinity of Westbrook College, and the brook follows a generally westerly course to its confluence with Capisic Brook south of the Maine Central Railroad spur line. The West Branch rises in the commercially developed area west of the Maine Turnpike (MNT) near Exit 8. Surface water

flows generally appear east of the turnpike, and the stream flows easterly to its confluence with Capisic Brook north of Sagamore Village. The respective drainage area of each brook is shown in the following Table 1.

Table 1 - Drainage Areas of Brooks

Brook	Square Miles	Acres
Capisic Brook above East Branch	0.49	313.6
East Branch	0.35	224.0
Capisic Brook above West Branch	0.99	633.6
West Branch	0.56	358.4
Capisic Brook at Dam	2.63	1683.4

About 57 percent of the watershed is developed with commercial, light industry, and residential neighborhoods. The significant open areas include the Evergreen Cemetery grounds, portions of Westbrook College, areas surrounding Capisic Pond, and the meadow north of Warren Avenue. Table 2 lists the existing land use or vegetative cover for the watershed in acres and in percentages. The 11 classifications were selected to facilitate the hydrologic modeling of the watershed. A further breakdown of the land use by subwatershed is contained in the section on Watershed Models (Land Use).

Table 2 - Watershed Land Use and Vegetative Cover

Land Use - Vegetative Cover	Area in Acres	Percentage
Impervious	12.9	0.8
Commercial	167.1	9.9
Residential (High)	154.3	9.2
Residential (Medium)	621.5	36.9
Hardwoods	131.5	7.8
Softwoods	125.7	7.5
Brush Land (Dry)	31.7	1.9
Brush Land (Wet/Edge)	155.4	9.2
Open Land (Bare)	15.8	0.9
Open Land (Grassland)	258.9	15.4
Water (Open)	8.6	0.5
Total	1683.4	100.0

NRCS has published a soil survey report for Cumberland County, and information on soils within the watershed can be found in the section on Watershed Models (Soils).

WATERSHED MODELS

GENERAL

The watershed models were developed to serve two purposes. The first was to assess the extent of flood damages from surface water (overland flow) and evaluate appropriate solutions. The second was to provide a screening tool for the conceptual alternative plans for Combined Sewer Overflow (CSO) abatement or elimination. The watershed was divided into 26 subwatersheds to facilitate the hydrologic analyses. Figure 4 on page 12 shows the location of the subwatersheds.

The watershed analysis utilized four computer based models: an ARC/INFO GIS database; a GRASS GIS; a NRCS hydrology model (TR20); and a NRCS hydraulic model (WSP2).

The ARC/INFO GIS database was maintained by the Casco Bay Estuary Project (CBEP). Data layers significant to the watershed models included: 1991 land use/cover, soils, topography, hydrography, and planimetric features.

Specific data layers were also available on a NRCS GRASS GIS for analytical purposes. In addition, Portland Public Works Department (PPWD), (formerly the Department of Parks and Public Works), personnel provided a digitized 'DXF' file of the one foot contour lines from the corridor maps. The topography, hydrography and planimetric map features were developed by photogrammetric methods from aerial photography obtained on May 15, 1992. The digital data sets were generated by Autocad. The watershed map was prepared at a scale of 1 inch = 200 feet with a contour interval of 2 feet. The flood plain corridor of Capisic Brook was also mapped at a scale of 1 inch = 50 feet and a contour interval of 1 foot. These products were the result of a contract let by the City of Portland.

Land Use

The land use data source was 1991 Landsat imagery. The initial interpretation was performed by the Forestry Department of the University of Maine. The digital data was edited by NRCS to reflect land use changes between 1991 - 1993. Aerial photography dated May 15, 1992, 1:2400 scale mapping, and field observations were the basis of the update. Table 3 is a tabular summary of the land use and vegetative cover, by subwatershed. The original GIS digital land use data was provided to NRCS by CBEP.

Table 3 - Subwatershed Land Use and Vegetative Cover(Acres)

Subwatershed		Urban Land Uses				Woodland		Brush		Open Land		Water
No.	Acres	Impervious	Commercial	Residential		Hardwoods	Softwoods	Dry	Wet/edge	Bare	Grass	Open
				High	Medium							
2	61.7	-	3.2	1.4	24.7	9.5	7.5	2.0	9.0	-	4.4	-
4	117.8	-	3.8	6.7	51.6	6.3	11.6	1.0	17.7	-	19.1	-
6	111.5	-	3.6	12.3	9.3	4.3	2.5	3.3	19.4	3.0	53.8	-
8	24.9	0.5	5.6	10.0	1.3	0.3	-	0.2	1.6	1.9	3.5	-
10	59.5	0.7	13.3	11.8	5.1	0.9	1.4	2.9	6.3	0.5	16.4	0.2
12	118.3	1.8	14.8	10.6	6.3	11.9	15.1	5.8	20.7	2.5	25.9	2.9
14	49.1	-	1.3	1.0	0.9	12.8	8.2	2.8	9.1	-	13.0	-
16	67.5	0.4	7.6	8.3	17.4	10.3	7.2	2.4	5.4	3.1	5.4	-
18	24.4	-	0.1	-	15.4	2.8	0.4	0.4	3.3	-	2.0	-
20	50.6	3.5	10.7	14.8	1.5	4.0	0.7	1.6	2.0	1.7	10.1	-
22	47.3	2.4	34.8	7.9	0.1	-	-	-	1.8	0.3	-	-
24	36.7	0.3	6.5	14.2	0.9	-	-	-	4.1	1.6	9.1	-
26	15.8	0.2	8.2	4.2	0.7	0.2	-	0.4	0.6	0.2	1.1	-
28	30.8	-	15.8	13.5	0.4	-	-	-	1.1	-	-	-
30	13.1	0.5	3.4	5.0	0.9	0.2	-	-	1.5	-	1.6	-
32	37.7	0.4	14.3	12.2	0.7	1.1	2.0	0.1	2.3	0.2	4.4	-
34	24.3	0.2	1.3	1.4	8.2	5.2	4.3	0.8	1.5	-	1.4	-
36	27.2	0.2	2.4	1.4	7.1	3.9	2.6	-	7.3	0.8	1.5	-
38	76.4	0.4	1.3	3.1	46.0	9.9	4.2	1.1	4.9	-	5.5	-
40	113.3	0.3	1.3	1.9	58.4	27.3	13.8	2.5	5.7	-	2.1	-
42	80.5	-	0.5	0.2	21.5	8.8	14.1	2.0	9.1	-	24.3	-
44	69.9	-	-	0.1	62.1	1.3	1.5	-	2.7	-	2.2	-
46	159.2	0.4	0.7	3.6	115.7	0.7	5.6	0.4	5.1	-	27.0	-
48	122.9	0.7	4.7	3.6	79.3	0.9	5.8	1.8	4.8	-	15.8	5.5
50	129.0	-	7.1	5.1	82.5	5.1	14.5	0.2	6.6	-	7.9	-
52	14.0	-	0.8	-	3.5	3.8	2.7	-	1.8	-	1.4	-
Totals	1683.4	12.9	167.1	154.3	621.5	131.5	125.7	31.7	155.4	15.8	258.9	8.6

Soils

The legend below (Table 4) is a listing of the soil map units mapped in Cumberland County which occur within the Capisic Brook Watershed.

Table 4 - Soil Survey Legend and Hydrologic Soil Group Attribute

Map Symbol	Soil Map Unit Name	Percent Slopes	Hydrologic Soil Group
Au	Au Gres loamy sand	-	C
BgB	Belgrade very fine sandy loam	0 - 8	C
BgC2	Belgrade very fine sandy loam	8 - 15, eroded	C
Bo	Biddeford silt loam	-	D
BuB	Buxton silt loam	3 - 8	D
BuC2	Buxton silt loam	8 - 15, eroded	C
Cu	Cut and Fill land	-	Var
DeB	Deerfield loamy sand	3 - 8	B
EmB	Elmwood fine sandy loam	0 - 8	C
HfC2	Hartland very fine sandy loam	8 - 15, eroded	B
HIB	Hinckley gravelly sandy loam	3 - 8	A
HnB	Hinckley-Suffield complex	3 - 8	A
HrC	Hollis fine sandy loam	8 - 15	D
HrD	Hollis fine sandy loam	15 - 25	D
HsB	Hollis very rocky fine sandy loam	3 - 8	D
HsC	Hollis very rocky fine sandy loam	8 - 20	D
HsE	Hollis very rocky fine sandy loam	20 - 35	D
Md	Made land	-	Var
MeC	Melrose fine sandy loam	8 - 15	C
PbB	Paxton fine sandy loam	3 - 8	C
Sn	Scantic silt loam	-	D
So	Scarboro sandy loam	-	D
SuE2	Suffield silt loam	25 - 45, eroded	C
Sz	Swanton fine sandy loam	-	D
Wa	Walpole fine sandy loam	-	C
Wg	Whately fine sandy loam	-	D
WmB	Windsor loamy sand	0 - 8	A
WmC	Windsor loamy sand	8 - 15	A
WrB	Woodbridge fine sandy loam	0 - 8	C

In the first column are the soil symbols as they appear in the soil survey report (maps). The first two letters in the symbol identify the soil series in a delineation.

The last letter in the symbol indicates the land slope of the map unit. The soil map unit name is given for each map symbol.

The soils data set was digitized from the Cumberland County Soil Survey (1974), and was provided to CBEP by NRCS. All pertinent attribute data was included. Figure 2 is a soils map of the watershed representing the digitized soil layer.

Soil properties influence the process of generation of runoff from rainfall, and they must be considered in methods of runoff estimation. When runoff for individual storms (single event) is the objective, the properties can be represented by a hydrologic parameter: *the minimum rate of infiltration obtained for a bare soil after prolonged wetting*. The influences of both the surface and the horizons of a soil are therefore included.

The hydrologic parameter, which indicates the runoff potential of a soil, is the qualitative basis of the classification of all soils into four groups. These groups are known as hydrologic soil groups: **A, B, C,** and **D**. Table 5 lists the percentage of each hydrologic soil group occurring in each subwatershed. Figure 3 shows the total percentage of each hydrologic soil group occurring within the watershed.

- **A** - (Low runoff potential). Soils having high infiltration rates even when thoroughly wetted and consisting chiefly of deep, well to excessively drained sands and gravels. These soils have a high rate of water transmission.

- **B** - Soils having moderate infiltration rates when thoroughly wetted and consisting chiefly of moderately deep to deep, moderately well to well drained soils with moderately fine to moderately coarse textures. These soils have a moderate rate of water transmission.

- **C** - Soils having slow infiltration rates when thoroughly wetted and consisting chiefly of soils with a layer that impedes downward movement of water, or soils with moderately fine to fine textures. These soils have a slow rate of water transmission.

- **D** - (High runoff potential). Soils having very slow infiltration rates when thoroughly wetted and consisting chiefly of clay soils with a high swelling potential, soils with a permanent high water table, soils with a claypan or clay layer at or near the surface, and shallow soils over nearly impervious material. These soils have a very slow rate of water transmission.

Figure 2 - Watershed Soils Map

Table 5 - Hydrologic Soil Groups

Subwatershed Number	Area Acres	% HSG A	% HSG B	% HSG C	% HSG D
2	61.7	14.9	6.3	27.9	50.9
4	117.8	26.0	0.7	13.5	59.8
6	111.5	3.7	0.0	53.6	42.7
8	24.9	0.0	0.0	80.7	19.3
10	59.5	31.2	0.0	27.6	41.2
12	118.3	18.7	0.0	29.3	52.0
14	49.1	0.0	0.0	31.4	68.6
16	67.5	0.0	0.0	55.8	44.2
18	24.4	0.0	0.0	74.3	25.7
20	50.6	5.2	0.0	7.7	87.1
22	47.3	0.0	0.0	60.7	39.3
24	36.7	0.0	0.0	37.4	62.6
26	15.8	0.0	0.0	100.0	0.0
28	30.8	30.1	0.0	29.6	40.3
30	13.1	0.0	0.0	100.0	0.0
32	37.7	45.3	0.0	21.9	32.8
34	24.3	21.4	17.1	36.8	24.7
36	27.2	0.0	7.5	60.5	32.0
38	76.4	5.7	13.1	20.1	61.1
40	113.3	1.0	18.7	39.4	40.9
42	80.5	16.9	36.6	30.0	16.5
44	69.9	0.0	37.7	55.9	6.4
46	159.2	30.2	5.6	22.4	41.8
48	122.9	15.9	6.0	59.4	18.7
50	129.0	10.5	10.3	53.4	25.8
52	14.0	31.6	0.0	36.1	32.3

A detailed description for each soil map unit is given in the Cumberland County Soil Survey Report. In addition, Soil Survey Data for Growth Management is a publication which provides an introduction to using soil survey information as a planning tool and a listing of soil types grouped according to their suitability, limitation and potential for numerous uses. For additional information, contact the **Cumberland County Soil and Water Conservation District** or the **Natural Resources Conservation Service, 381 Main Street, Suite 3, Gorham, Maine, 04038,** Telephone **(207) 839-7839** or **(207) 839-7842,** respectively.

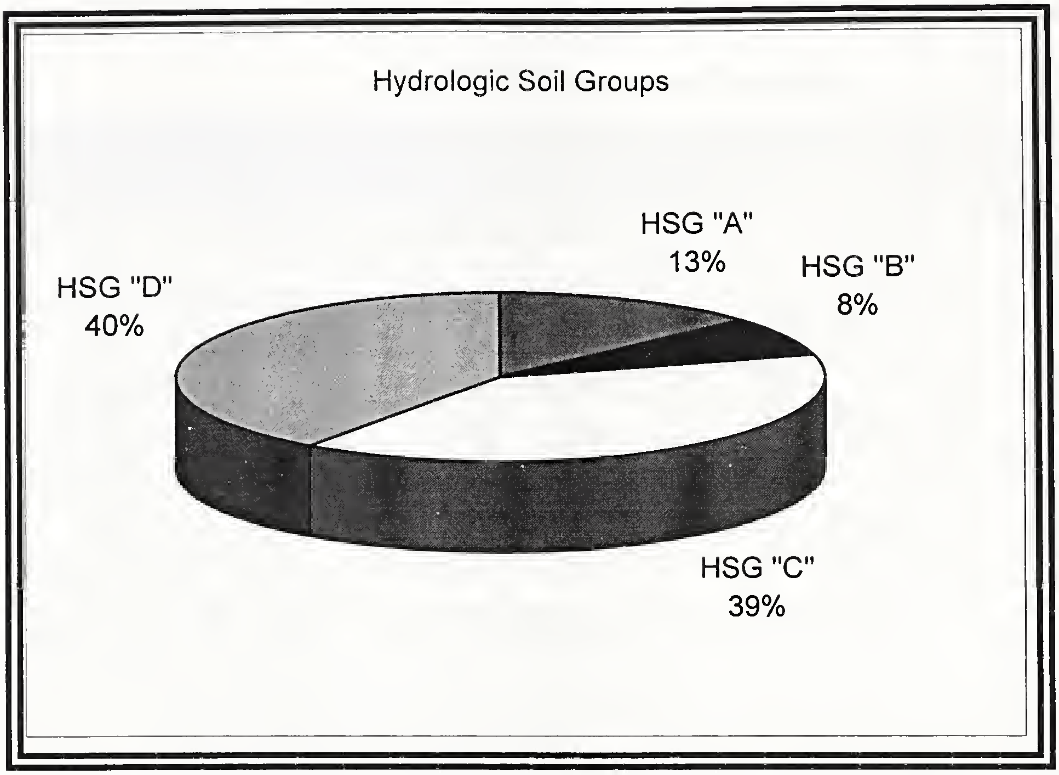


Figure 3 - Watershed Hydrologic Soil Groups

HYDROLOGY

TR20 is the designation for a watershed computer model entitled Computer Program for Project Formulation-Hydrology. The program is a physically based event model which computes direct runoff resulting from any synthetic or natural rainstorm. There is no provision for recovery of initial abstraction or infiltration during periods of no rainfall during an event. It takes into account conditions having a bearing on runoff, develops a hydrograph, and routes the flow through stream channels, reservoirs, and natural storage areas. Routed hydrographs are combined with those from other tributaries. Provisions for hydrograph separation by branching or diversion of flow and the addition of baseflow are included. TR20 does not have a groundwater component.

Peak discharges, their times of occurrence, volumes of runoff, water surface elevations, and duration of flows can be computed at any desired cross section or structure (reservoir).

The detailed hydrologic analyses were conducted to establish the peak discharge-frequency relationships for each flooding source studied.

Capisic Pond Dam was selected as the downstream limit for development of the hydrologic and hydraulic models in this study. It is just above the confluence with the Fore River, and no damageable property exists below it. The drainage area of the Capisic Brook Watershed at the dam is 2.63 square miles. There are no stream gaging stations within the watershed, nor do any surface water flow records exist. Estimates of high water at seven locations during Hurricane Bob in August 1991 were obtained from various sources and used to verify the validity of the models.

Initially, the watershed boundary and subwatershed delineations were determined using the ARC/INFO software and the digital elevation data layer. (A secondary goal of this project was to maximize the use of the capabilities of the GIS to provide planning and management opportunities in the future.) The boundaries were then adjusted to reflect infrastructure changes to the landscape, based on planimetric map features. The watershed delineation was based strictly on topography, and questionable areas were field checked for particular drainage features. A total of 26 subwatersheds were identified ranging in size from about 13 to 159 acres. The area calculations were determined by the GIS software. Figure 4 shows the watershed boundary, and the 26 subwatersheds.

Routine manual/computer aided computations were made for subwatershed times of concentration and flood routing reach lengths, with the aid of the large scale topographic maps. Composite runoff curve numbers were generated with the GRASS GIS overlaying the soils and land use data layers, along with the watershed/subwatershed delineation layer.

Stage storage and discharge rating tables were prepared for existing ponds and selected storage areas. The existing ponds modeled as storage areas were Capisic Pond and the wetland north of Warren Avenue. The other selected storage areas were controlled by earth embankments, usually road fills, with culvert conduits. Valley cross section ratings used to reach route the flood hydrographs were developed using WSP2, as were the hydraulic discharge ratings for storage structures except Capisic Pond Dam. The rating for Capisic Pond Dam was developed from design plans which represented the most recent modifications.

Historical rainfall data from the Portland, Maine Weather Service Forecast Office (WSFO) was used to run and calibrate the TR20 data model. Since there are no historical hydrographs available for the watershed, calibration or verification of the hydrology model must be done in conjunction with the hydraulic model (WSP2). Hourly data for the August 19, 1991 Hurricane Bob storm was used to generate peak discharges and runoff volumes simulating the flood event.

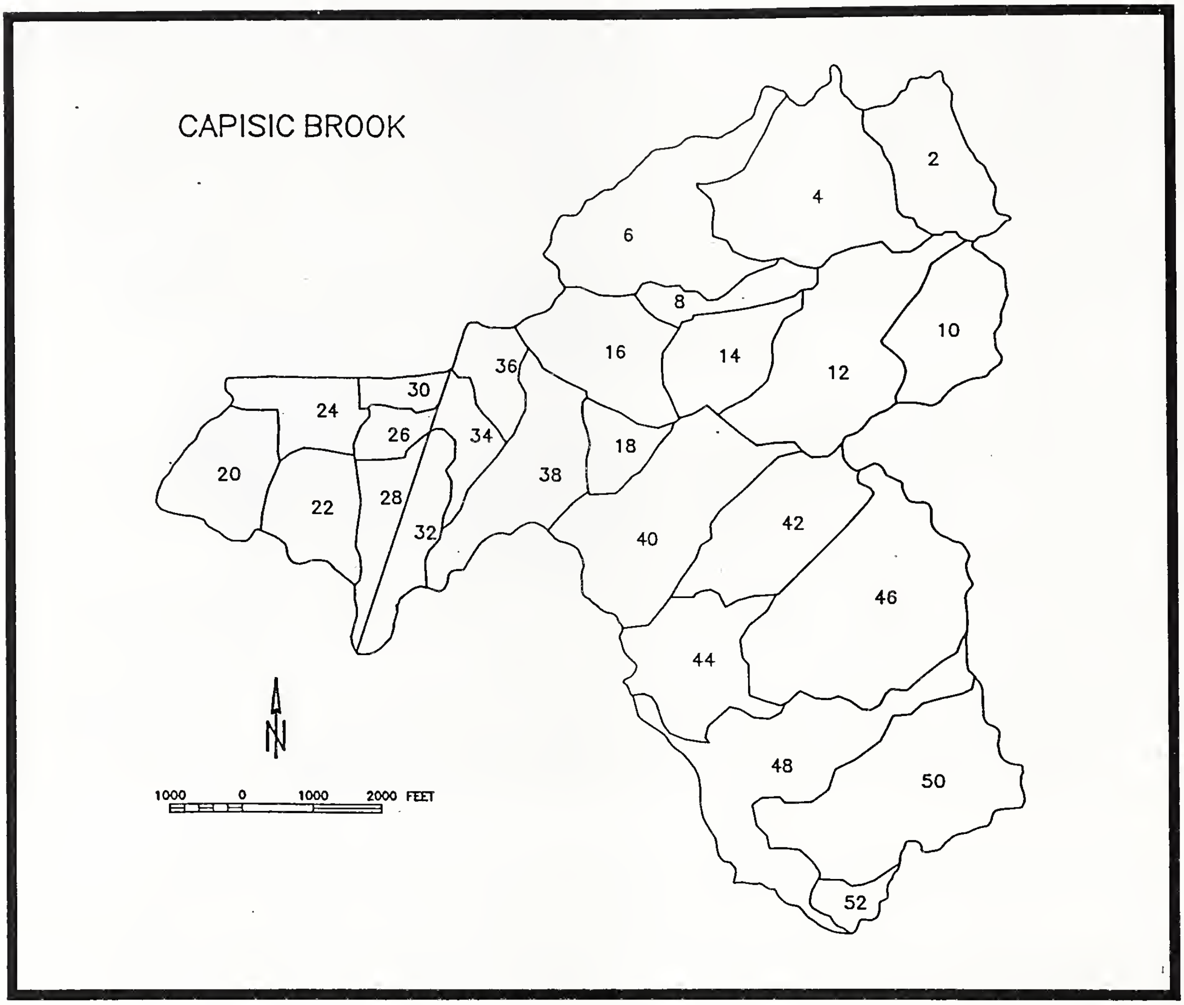


Figure 4 - Subwatershed Map

Review of the precipitation record for August 1991 showed that no rainfall occurred during the 5 day period preceding the hurricane. NRCS methodology characterizes this as an antecedent runoff condition of ARC-I, drier than average during the normal growing season. (An antecedent runoff condition representing the average conditions would be ARC-II, while conditions considered wetter than normal would be ARC-III.) Therefore Hurricane Bob was evaluated with an ARC-I, which results in a smaller volume of runoff than 'average conditions'. The recorded rainfall depth of Hurricane Bob was 7.83 inches over a 23 hour period.

HYDRAULICS

The Water Surface Profile 2 (WSP2) computer program can provide information on elevation, discharge, flow area, and flooded area at specified locations along a stream valley. The program can compute up to 15 water surface profiles in a pass through the watershed. The standard step method, with some modifications, is used to compute profiles between valley cross sections. At a road crossing, head losses can be calculated through a bridge opening, culverts, or a combination. WSP2 is capable of computing flow profiles for subcritical and critical flow. Valley cross section hydraulic ratings, and structure ratings generated by WSP2, are used by the TR20 program to reach-route flood hydrographs through valley reaches and reservoir-route through storage areas.

The detailed hydraulic studies were conducted to provide estimates of the elevations of floods of the selected recurrence intervals.

A WSP2 model was developed for Capisic Brook from Capisic Pond Dam upstream to Forest Avenue; for the West Branch upstream to the Maine Turnpike; and for the East Branch upstream for a distance of 3,300 feet.

Field surveys were conducted during the summer of 1993 by personnel of the Portland PWD. All surveys were referenced to the National Geodetic Vertical Datum (NGVD). The geometry and elevations of all culverts and road centerline elevations at stream crossings were obtained along with channel wet sections for locations covered by the 1:600 mapping. For locations covered only by 1:2400 scale mapping, full cross sections were surveyed. The culverts for existing conditions were modeled as field surveyed. They were not modeled as clean if sediment or distortion was accounted for in the field measurements; however, no debris obstructions or icing was assumed. The flood elevations determined are valid only if hydraulic structures remain unobstructed, and do not fail.

The road profiles and overbank or flood plain sections were taken from the 1:600 maps (1 foot contours). These maps were also used to locate the cross sections and establish the stream profile stationing.

Channel and overbank roughness factors (Manning's "n") used in the hydraulic computations were assigned on the basis of field inspection. The roughness factors ranged from 0.035 to 0.060 for the channel, and from 0.055 to 0.120 for the overbank areas. (Manning's "n" is the primary variable, along with the segmenting of the cross section, to facilitate describing the section via multiple values of Manning's "n". Up to six segments may be defined for each cross section.) Photographs of culverts and stream reaches were taken to document field conditions encountered in 1993-1994.

Channel and valley cross section, and road and culvert, data were used in the hydraulic model. Initially, this model was processed for a wide range of discharges to develop the reach routing ratings required by the TR20 model. (Initially the 2-year through the 500-year discharge values are not known. Therefore, the hydrology model requires hydraulic ratings which will encompass the "wide range" between the extremes.) Starting elevations for each profile were determined from a hydraulic rating of the Capisic Pond Dam.

EVALUATION PROCESS

The present condition models (TR20 and WSP2) were used to describe the extent of the existing flooding problem. The flood damage assessment (overland flow) was accomplished using Hurricane Bob as the "key storm", and synthetic storms with return periods of 2-, 5-, 10-, 25-, 50-, 100-, and 500-years. The rainfall depths for each synthetic storm were taken from Weather Bureau Technical Paper 40. The depth for the 500-year storm was extrapolated. The duration of each synthetic event was 24 hours. Refer to Table 6 for the precipitation values used (Annual Graph).

Table 6 - 24-hour Precipitation-Frequency

Return Period (years)	Partial Duration (inches)	Conversion to Annual Series	Annual Map 1/ (inches)	Annual Graph (inches)
1	2.5	0.81	2.0	2.0
2	3.0	0.88	2.6	2.6
5	3.8	0.96	3.6	3.6
10	4.4	0.99	4.4	4.3
25	5.2	1.00	5.2	5.1
50	5.6	1.00	5.6	5.7
100	6.3	1.00	6.3	6.3
500	-	-	/2	7.8

1/ 1Year based on extrapolated conversion factor in TP-40
2/ Extrapolated from plot of 1- 100 year values.

The discharges from the TR20 model for Hurricane Bob were prorated to each cross section in the hydraulic model. The TR20 model calculates a discharge at the foot of each reach or subwatershed. These locations have a known drainage

area. The locations between calculation points are assigned discharges based on their relative drainage areas. The model was processed to produce a flood profile representing the high water surface during Hurricane Bob. The elevations of the water surface at points along the brook were compared to approximate high water observations. Most descriptions of the depth or height of the water were general, such as: *2 feet over the road*, *below basement window*, or *about even with the ground at the house*. A few high water observations were more specific, such as: *even with top of the deck, level with top of first step, or level with bulkhead*. Information regarding the status of overtopping of several road crossings was not available. The computed profile agreed reasonably well with the available high water observations and interview data.

The WSP2 model was then processed to produce profiles of the synthetic evaluation storms with return periods (recurrence interval) of 2-, 5-, 10-, 25-, 50-, 100-, and 500-years. These events, commonly termed the 2-, 5-, 10-, 25-, 50-, 100-, and 500-year floods, have a 50-, 20-, 10-, 4-, 2-, 1-, and 0.2-percent chance, respectively, of being equaled or exceeded during any one year. Elevation-frequency data was generated at each cross section to facilitate the delineation of the flood plain and the economic flood damage analysis.

Although the recurrence interval represents the long term average period between floods of a specific magnitude, rare floods could occur at short intervals or even within the same year. The risk of experiencing a rare flood increases when periods greater than 1 year are considered. For example, the risk of having a flood which equals or exceeds the 100-year flood (1-percent chance of annual exceedance) in any 50-year period is approximately 40 percent (4 in 10), and for any 90-year period, the risk increases to approximately 60 percent.

FLOOD PLAIN DELINEATION

The delineation of specific flood plains was accomplished using the NRCS GRASS Geographic Information System, and software utilities provided by the Corps of Engineers (COE). Currently, the software utilities, Flood Plain Analysis Tools (F-tools), represent a modest beginning towards integrated computer tools for a large and complex domain -- flood plain management.

The primary goal in using F-tools in this study was to provide a GIS link between the hydraulic model results and delineation of the respective flood plains. The map generation capabilities of the GRASS/MAPGEN GIS would also accomplish any drafting needs. In addition, the post analysis digital files would provide more resource management flexibility than manually produced exhibits.

The input data requirements were a Digital Elevation Model (DEM) of the flood plain corridor maps, and flood profile elevations for each cross-section utilized in the hydraulic analysis. The hydraulic data had to be in the HEC-2 (COE hydraulic model) output file format. Portland PWD personnel provided a digitized 'DXF' file of the 1 foot contour lines from the corridor maps. The data was converted by GRASS to a raster elevation map of the stream corridor. The location of each valley and road cross section was digitized from the 1:600 corridor maps. The flood profile elevation data was converted to a HEC-2 output format and entered into the database. While seven evaluation floods were provided to the database, only the 5-, 25-, and 100-year floods were selected to be delineated. The plotted Flood Profiles are in Appendix A.

GRASS software was then used to interpolate the water surface between each cross section. (The F-tool module resulted in clipping the extreme edges of the flooded areas.) A water surface raster map was thus generated for each flood event. The flood delineation map resulted from: FLOOD DELINEATION [5,25,100] = GROUND ELEVATION $\leq$ WATER SURFACE ELEVATION [5,25,100].

The flood delineation map layers were converted to vector maps and smoothed to eliminate the stair-step appearance created by the raster-to-vector conversion process. These vector layers were then combined with the other vector layers of the corridor maps and plotted. A total of 17 individual map sheets, each depicting the three selected flood events, were produced. The Flood Plain Maps are in Appendix B. Table 7 below lists the acreage of the three flood events delineated.

Table 7 - Acres of Delineated Flood Plain

Stream	5-Year	25-Year	100-Year
East Branch	40.4	57.6	65.0
West Branch	72.4	81.6	86.7
Capisic Brook	470.8	595.6	826.4
Totals	583.6	734.8	978.1

All buildings within the 100-year flood plain were identified and compared to a list of buildings known to have incurred flood damage in 1991. Additional field inspection of these buildings and interviews with owners and/or neighbors resulted in adjustment to the flood plain lines in a few areas. In these instances the digital maps did not completely reflect the placement of fill adjacent to the building foundations.

FLOOD DAMAGE INVESTIGATIONS

FLOOD DAMAGE EVALUATION

During the summer and fall of 1993, and the spring of 1995, the Natural Resources Conservation Service (NRCS) conducted economic field investigations within the Capisic Brook Watershed to determine the extent of potential flood damage from overland flows. Those areas identified in the Plan of Work plus others were evaluated. The following summarizes the results of those investigations according to flood plain location:

- **Capisic Pond to Brighton Avenue** - All buildings are topographically high and appear well above the 100-year flood elevation. Any problems in this reach are primarily associated with stormwater backup; surface flooding is not a major concern.

- **Brighton Ave. to Dennett Street** - Damage caused by overland flows was noted to structures and contents at 33 Violette Avenue and 44 Violette Avenue. In each case water entered through an above ground opening and flooded finished living areas within the home. The High Water Mark (HWM) from Hurricane Bob at this location was estimated to be even with the deck of the footbridge in the rear of house number 44.

  At 86 Dennett Street, substantial damage occurred to the owner's lawn and driveway although water did not reach the home. Culvert failure at this location was also identified. Diagonally across the street at 79 Dennett Street the HWM was approximately 1 inch below the bottom of the basement window. Although water entered the basement of this home, it was primarily the result of sewage backup.

- **Dennett Street to Holm Avenue** - Occupants of nearly all of the homes adjacent to the brook in this reach were interviewed. Again, stormwater backup and not surface flow was the cause of most damages sustained and, in several instances, these damages were significant. HWMs from Hurricane Bob included the base of the maple tree in front of 201 Taft Avenue and the top of the first step on the side of the home at 189 Holm Avenue.

- **Upstream of Holm Avenue** - Due to widespread reports of previous flooding at the Holiday Inn, damage interviews were conducted in the low lying areas at this vicinity. In addition to the manager of the Holiday Inn, others interviewed included managers and/or owners of the Lee Collision Repair Center, Verrillo's Restaurant, and the Howard Johnson's hotel. In no case, including the Holiday Inn, were structural damages incurred from Hurricane

Bob. Nearly all occupants, however, complained of flooded parking lots being a common problem during periods of heavy rainfall.

Historically, only the Holiday Inn had reported water entering the building. This occurred in 1990 and was the result of a drainage system inadequate to control runoff from the hillside south of the building. Having incurred several thousand dollars in damages during the 1990 flood, management assembled a group of engineering experts to solve the problem. Shortly thereafter work began on drainage modifications in the parking lot south of the Inn. Completed prior to Hurricane Bob, these modifications proved effective in controlling runoff. As a result, future flooding at this location is highly unlikely.

During the first three months of 1995 the information collected above was compared to the results of the completed flood plain delineations of the 5-, 25- and 100-year events. Additional interviews were conducted to verify the delineations and the preliminary damage analysis. With one exception, the interviews substantiated the previous findings. The exception was found at 7 Poe Street (downstream of Taft Avenue), where the water in the basement reached nearly 3 feet deep during Hurricane Bob.

Overall results of this comparison confirm that, although flooding does occur in the watershed, damages from overland flow are minimal. It should be noted that of the 15 property owners reporting damage from overland flow during Hurricane Bob, only 7 actually received water inside the structure; the remainder were limited to lawn and driveway type damages.

FLOODPROOFING FLOOD PRONE BUILDINGS

General

Damage surveys and interviews done by the City of Portland and the NRCS following Hurricane Bob, revealed that the vast majority of building damage was caused by sanitary sewer and storm drain backup as opposed to overland flow of water from Capisic Brook and its tributaries. In addition, some buildings had basement floor drains which eventually emptied directly to the brook. In other cases, storm drains and catch basins had direct open outlets to the brook. Sanitary sewer and storm drainage are being addressed by Portland and its consultants as part of the Combined Sewer Overflow (CSO) abatement program. The NRCS evaluations are limited to alternatives for reducing flood damage from the overland flooding of streams.

Methodology

Buildings within the 100-year flood plain (generally the accepted standard for evaluating flood prone property) were identified as candidates for further evaluation. In order to assess the significance of the delineation, a sample of property owners was interviewed to determine if the buildings had actually been damaged from overland flooding during Hurricane Bob. Since the flood depths associated with Hurricane Bob are similar to those of the 100-year flood (within 0.1 to 0.4 feet), a judgment was made that buildings that were not damaged by Hurricane Bob did not warrant further study. Damages caused only by such an infrequent flood are not enough to justify remedial action.

Recommendations

Based on the evaluation of *surface water flooding*, the buildings listed in Table 8 appear to merit some type of remedial action.

Table 8 - Buildings Suggested For Remedial Action

Map No.	Address	Recommendation
13	33 Violette Avenue	Utility room addition
14	44 Violette Avenue	Floodwall and drainage
14	79 Dennett Street	Utility room addition
17	7 Poe Street	Fill, floodwall, and drainage
17	189 Holm Avenue	Utility room addition

It is important to understand that recommendations are based on limited map and field information. The complete evaluations, including cost estimates, are part of the substantiating data and are available through the City of Portland Public Works Department. If property owners are interested in floodproofing their homes, a qualified engineer should be consulted. More detailed study may indicate other measures better suited to individual buildings.

There are several houses, particularly in the vicinity of Brighton Avenue and Alden Circle, that may have floor drains that outlet to the brook. Where these conditions exist, check valves should be installed to prevent backups. In addition, there are catch basins at Alden Circle that drain to the brook. A flap gate should be installed on the outlet pipe to prevent Capisic Brook from backing up, as occurred during Hurricane Bob.

HYDRAULIC IMPROVEMENTS

A frequently voiced local perception is that the Capisic Pond Dam and some road crossings (culverts) are restrictive or under-sized. In an effort to demonstrate to what extent this view may or may not be true, several alternative

Table 9 - Hydraulic Alternatives

ALTERNATIVE	CAPISIC POND DAM	CAPISIC STREET	LUCAS STREET	BRIGHTON AVENUE	VIOLETTE AVENUE	DENNETT STREET
A	X	0	0	0	0	0
B	0	X	0	0	0	0
C	X	X	0	0	0	0
D	X	X	0	X	0	0
E	X	X	0	X	X	0
F	X	X	0	X	X	X
G	X	X	X	X	X	X
H	0	0	0	X	0	0
I	0	0	0	0	X	0
J	0	0	0	X	X	0
0= EXISTING CULVERT				X= IMPROVEMENT BELOW		

LOCATION	DESCRIPTION
CAPISIC POND DAM	Existing -3 stage weir (8 ft.- 4 ft.- 67 ft.) **Modified - 2nd. stage weir extended 25 feet (8 ft.- 29 ft.- 42 ft.)**
CAPISIC STREET	Existing -One 6 ft. x 13 ft. wide, concrete box culvert **Modified - Box culvert enlarged to 6 ft. x 20 ft. wide**
LUCAS STREET	Existing -Two 6 ft. x 8.9 ft. wide, concrete box culverts **Modified - Enlarged box culverts to two 6 ft. x 10 ft. wide**
BRIGHTON AVENUE	Existing -One 5.8 ft. x 12.2 ft. wide, concrete box culvert **Modified - Enlarged box culverts to two 6 ft. x 10 ft. wide**
VIOLETTE AVENUE	Existing -One 7 ft. x 10 ft. wide, corrugated metal pipe arch culvert **Modified - Replaced with two box culverts 6 ft. x 8 ft. wide**
DENNETT STREET	Existing -One 6.5 ft. x 9.7 ft. wide, corrugated metal pipe arch culvert -One 3 ft. ID, corrugated metal pipe culvert **Modified - Replaced with two box culverts 6 ft. x 8 ft. wide**

modifications or culvert replacements were evaluated from Capisic Pond to Dennett Street. Table 9 shows the alternative components and a description of

the modification. In addition, the dam weir was assumed to be lengthened by 25 feet. The normal pond level was not altered, nor was the primary notch. The secondary weir level was increased enough to evaluate the effect through the Capisic Street structure.

Incrementally, the Capisic Street through Dennett Street culverts were assumed to be replaced by larger culverts. The resulting water surface elevations were tabulated and tables prepared which showed *the difference in feet relative to existing conditions for each modification*. Alternative A is modification only of Capisic Pond Dam, while Alternative G reflects a modification of all structures. Tables 10-12 show the actual effect of the modifications for three flood events. Figure 5 is a graphical display of the data shown in Table 11.

It should be noted that this analysis only reflects the hydraulic effects of the improvements, and does not evaluate the possible hydrologic effects. These could include possible increases in discharge, for some flood events, due to reduced channel and flood plain storage.

Table 10 - Hydraulic Alternatives - 5 Year Event

	CAPISIC POND DAM	CAPISIC STREET	LUCAS STREET	BRIGHTON AVENUE	VIOLETTE AVENUE	DENNETT STREET
EXISTING FLOOD ELEVATION	33.8	34.7	37.4	38.5	41.2	42.5
ALTERNATIVE	**DIFFERENCE IN FEET RELATIVE TO EXISTING ELEVATION**					
A	-0.5	-0.5	-0.1	-0.1	-0.1	0.0
B	0.0	-0.5	-0.2	-0.1	-0.1	0.0
C	-0.5	-0.9	-0.2	-0.1	-0.1	0.0
D	-0.5	-0.9	-0.2	-0.8	-0.3	0.0
E	-0.5	-0.9	-0.2	-0.8	-2.4	-0.2
F	-0.5	-0.9	-0.2	-0.8	-2.4	-1.9
G	-0.5	-0.9	-0.4	-0.9	-2.4	-1.9
H	0.0	0.0	0.0	-0.6	-0.2	0.0
I	0.0	0.0	0.0	0.0	-1.9	-0.2
J	0.0	0.0	0.0	-0.6	-2.2	-0.2

No specific recommendation is made regarding culvert replacement on the basis of this analysis. The hydraulic relationships that exist between the road crossings is the best inference that can be made. This is due to the assumed replacement sizes, of which there are many variations, selected for this analysis. Likewise, there are many different modifications that could be made to Capisic Pond Dam. However, the upstream effect of most alterations could be negated

by the existing Capisic Street culvert along with the extensive growth of cattails in the inlet area of the pond.

Table 11 - Hydraulic Alternatives - 25 Year Event

	CAPISIC POND DAM	CAPISIC STREET	LUCAS STREET	BRIGHTON AVENUE	VIOLETTE AVENUE	DENNETT STREET
EXISTING FLOOD ELEVATION	34.3	36.5	39.3	41.6	42.4	43.1
ALTERNATIVE	DIFFERENCE IN FEET RELATIVE TO EXISTING ELEVATION					
A	-0.4	-0.5	-0.1	-0.3	-0.1	0.0
B	0.0	-1.2	-0.3	-0.4	-0.1	0.0
C	-0.4	-1.5	-0.5	-0.6	-0.1	0.0
D	-0.4	-1.5	-0.5	-1.9	-0.4	-0.1
E	-0.4	-1.5	-0.5	-1.9	-1.3	-0.2
F	-0.4	-1.5	-0.5	-1.9	-1.3	-0.7
G	-0.4	-1.5	-0.9	-2.2	-1.5	-0.9
H	0.0	0.0	0.0	-1.4	-0.3	0.0
I	0.0	0.0	0.0	0.0	-0.3	0.0
J	0.0	0.0	0.0	-1.4	-1.0	-0.2

Table 12 - Hydraulic Alternatives - 100 Year Event

	CAPISIC POND DAM	CAPISIC STREET	LUCAS STREET	BRIGHTON AVENUE	VIOLETTE AVENUE	DENNETT STREET
EXISTING FLOOD ELEVATION	34.8	38.6	40.9	42.6	43.0	43.6
ALTERNATIVE	DIFFERENCE IN FEET RELATIVE TO EXISTING ELEVATION					
A	-0.4	-0.4	-0.1	0.0	0.0	0.0
B	0.0	-2.1	-0.4	-0.1	0.0	0.0
C	-0.4	-2.4	-0.4	-0.1	0.0	0.0
D	-0.4	-2.4	-0.4	-0.7	-0.2	-0.1
E	-0.4	-2.4	-0.4	-0.7	-0.5	-0.2
F	-0.4	-2.4	-0.4	-0.7	-0.5	-0.4
G	-0.4	-2.4	-0.8	-1.0	-0.6	-0.4
H	0.0	0.0	0.0	-0.5	-0.2	-0.1
I	0.0	0.0	0.0	0.0	0.0	0.0
J	0.0	0.0	0.0	-0.5	-0.4	-0.1

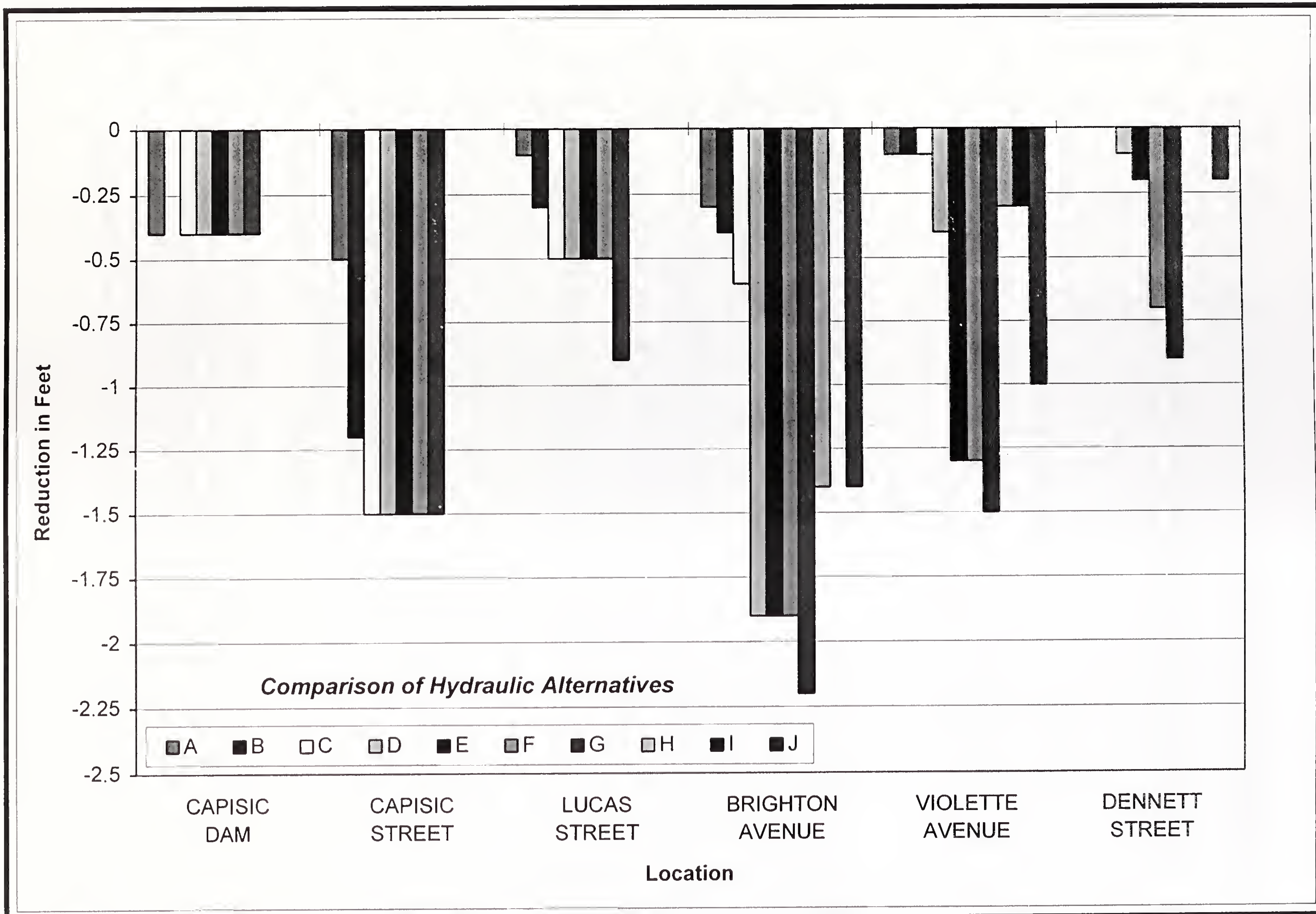


Figure 5 - Comparison of Hydraulic Alternatives (25-Year)

CSO ABATEMENT SCREENING

This analysis utilized the TR20 hydrology model to evaluate three alternative scenarios for reduction or elimination of Combined Sewer Overflows. The existing condition TR20 data set was altered to reflect the following potential measures:

- Alternative 0 is the **existing condition** against which the others are measured;
- Alternative 1 **maximizes detention** with overflow to the brook;
- Alternative 2 **maximizes treatment** at the Waste Water Treatment Facility (WWTF);
- Alternative 3 is a **mix of Alternatives 1 and 2**.

The existing hydrologic model included seven locations where storm runoff was temporarily stored during and following rainfall. Road fill embankments and wetland areas are frequently as effective in detaining storm runoff as dams. In addition there are three locations within the watershed where stream flow can enter the combined sewer system (brook inlets). The existing model estimated the maximum flow rate that could enter the sewer at each location, with the excess flowing downstream. At the first combined sewer constriction down gradient, the storm flow in the sewer would be reduced to the capacity rating. The excess flow would be returned to the brook (overflow)

To evaluate Alternatives 1 - 3 required several changes to the existing model. These consisted of:

- separation of impervious areas from each subwatershed where new detention facilities were planned;
- recalculation of composite runoff curve numbers for the pervious areas;
- determination of time of concentration values for the impervious areas;
- development of storage and discharge ratings for the detention ponds;
- new tables reflecting increased storage for three existing sites;
- elimination or modification of the brook inflow sites.

The basic assumptions for the detention ponds, which would receive runoff from the separated **impervious** areas, were that the spatial characteristic was not fixed, the shape was rectangular and the depth was 5 feet. The ponds were to function as infiltration facilities with an overflow weir of 15-20 feet long. The assumed infiltration value was 0.35 inches/hour. The excess inflow would discharge via the weir to the brook or sewer depending on the alternative being modeled.

Vortex valves were to be employed at several locations as a component in one or more alternatives. These were modeled by truncating the appropriate hydrograph at a discharge equal to the maximum rate allowed by the sewer capacity. The excess was either conveyed to a detention pond or allowed to "pond" on the street, depending on location.

The evaluation consisted of analyzing two historical storms: November 1966, a 2-year event; and November 1988, a 5-year event. The analyses assumed average antecedent runoff conditions (ARC-II). Seven detention ponds and one sediment pond were added to the model, along with enlarging three existing storage areas. Table 13 lists storage sites by subwatershed and whether or not the site is a component of the respective alternative.

Table 13 - CSO Alternative Detention Pond Matrix

Site #	Subwatershed	Description	ALT 0	ALT 1	ALT 2	ALT 3
54	48	Capisic Pond	E	E	E	E
48	48	Detention Pond	O	X	X	X
46	46	Brook Inlet	E	M	M	M
44	44	Detention Pond	O	X	O	X
38	38	Detention Pond	O	X	X	X
34	34	Detention Pond	O	X	X	X
31	34	Sediment Pond	O	X	O	X
30	30	Turnpike No.Conduit	E	E	E	E
26	26	Turnpike So.Conduit	E	E	E	E
13	14	Detention Pond	O	X	O	X
10	10	Detention Pond	O	X	O	X
6	6	Warren Ave Wetland	E	E	M	M
5	6	Detention Pond	O	X	X	X
4	4	Brook Inlet	E	E	E	E
2	2	Brook Inlet	E	E	M	M

E - Existing storage site **X - Detention site employed**
O - Site not employed **M - Modified/enlarged existing site**

Since the focus of this analysis is on alleviating or eliminating the CSOs, the evaluation is presented relative to a specific CSO. The CSO # is not related to the subwatershed designations.

CSO 43 - Warren Avenue

(Stormwater Capacity = 2 CFS)

All three Alternatives are designed to limit stormwater conduit discharges to the CSO regulator capacity, thereby eliminating CSO overflows. No increase in discharge occurred in the East Branch for the two historical evaluation storms. Alternative 3 is the most effective.

CSO 42 - Warren Avenue

(Stormwater Capacity = 10 CFS)

Alternative 3 has the potential to be the most effective, in that it allows for WWTF treatment of the earliest runoff from separated areas. Removal of the Brook Inlet west of the Mt. Sinai Cemetery, along with restricting flow to the West Side Interceptor Sewer (WSIS) at Forest Avenue, allows for the separated areas to discharge primarily to the WSIS. (The 2-year storm outflow discharge is 9 CFS.) The excess flows at Forest Avenue would flow in a reestablished waterway. The excess flow from the separated areas of Subwatersheds 2, 4, 6, and 8 would go to one of the two detention ponds, with overflow to the brook. The additional storage at Forest Avenue resulted in about a 10-percent reduction in peak outflow.

Mitigation of increased brook flow above Warren Avenue (increased flood stages up to 3 feet), can be accomplished by increasing the storage at the existing wetland area in Subwatershed 6. Providing an additional storage of 25 acre-feet (AF) between elevation 57 and 62 would accommodate the two historical events. The 1988 storm nearly equaled the inlet capacity of the "Mt. Sinai Brook Inlet". Therefore, larger storms should not require further mitigation. This should be verified in design.

All three alternatives resulted in slightly reduced discharges below CSO 42, south of Warren Avenue, at the confluence with the East Branch.

CSO 41 - Holm Avenue

(Stormwater Capacity = 1 CFS)

A modification of Alternative 2, to send up to 1 CFS (from separated area) to WWTF, with the excess to the detention pond and overflow discharge to the brook, is suggested. This sequence seems to maximize the volume treated, and minimize detention pond size.

CSO 40 - Pinecrest Extension

(No longer in service)

All three Alternatives are the same, employing a detention pond to treat runoff from separated areas. The area outside the topographic watershed was not included in the model. (This would only affect the size of the detention pond.) For each alternative there was an average 1-percent decrease in peak discharge for each event at the mouth of the West Branch.

CSO 38 - Brighton Avenue

(Stormwater Capacity = 1 CFS)

Alternative 3 is the most effective, with first flush (up to 1 CFS) to the WWTF, with excess to a detention pond. The area outside the topographic watershed was not included in the model.

CSO 36 - Capisic Pond Dam

(Stormwater Capacity = 13 CFS)

The major intervening Subwatershed is number 46, Wayside - Alden Circle Brook Inlet. Added storage to the existing detention area resulted in a 50 percent reduction in peak outflows for the two events analyzed. However the 2-year outflow equals the CSO discharge capacity. If upstream areas are contributing flow to the WSIS then the CSO should overflow. Limiting flow to the WSIS with remaining flow discharged to the brook downstream of Lucas Street is suggested.

Detention pond(s) in Subwatershed 48 and/or 50 need 6.2 AF of storage for one inch of runoff from separated areas. The runoff volume from the 1966 (2- year) storm is 19.5 AF.

Discharges in the brook for the two events are equal to or less than existing conditions for all three alternatives between Warren Avenue and Lucas Street. The current increases below Lucas Street are minor, and result from Subwatershed 46 discharging to the brook and/or the current undersized detention pond in Subwatershed 48.

CIVIL RIGHTS IMPACT ANALYSIS

The Secretary of Agriculture has determined that in order to carry out Federal civil rights laws and policies there is a need for USDA agencies to identify and address the civil rights implications of proposed agency actions in their management and decision making procedures. To that end, the Secretary has directed that USDA agencies identify and address the civil rights implications of proposed policy actions before those actions are approved and implemented.

Civil rights impacts are those consequences of proposed policy actions which, if implemented, will negatively and disproportionately affect the socially and economically disadvantaged, minorities, women, or persons with disabilities who are employees, program beneficiaries, or applicants for employment or program benefits in USDA conducted or assisted programs by virtue of their race, color, national origin, sex, religion, age, disability, political beliefs, or marital or familial status.

This Flood Plain Management Study was conducted in support of the *Capisic Brook Greenbelt/Stormwater Abatement Study*. This report summarizes the studies conducted by the NRCS within the Capisic Brook Watershed. The focus of NRCS activities was confined to evaluation of existing flood hazards and flood damage, and hydraulic and hydrologic modeling support for the Stormwater Abatement Study. The study identified the flood hazards that currently exist, evaluated potential actions to lessen the hazards, and provided a hydrologic analysis of the Stormwater Abatement Study alternatives put forth by the City of Portland's consultant.

The technical information provided in this report, and in the separate Appendices, will be useful to the City of Portland in identifying flood plain areas, properties subject to flooding, and potential remedies to existing flood problems. The computer data files and Geographic Information System (GIS) data layers will be useful in improving and managing the resources of the watershed.

The publication of this document concludes NRCS activities with respect to this Study. Since no NRCS policy action or program implementation is anticipated or recommended, NRCS's civil rights impact analysis concludes that no protected groups will be negatively or disproportionately affected as a result of this study.

GLOSSARY

CFS or cfs - Cubic feet per second. Used to describe the amount of flow passing a given point in a stream channel. One cubic foot per second is equivalent to approximately 7.5 gallons per second.

Channel - A natural or artificial watercourse with definite bed and banks to confine and conduct flowing water.

Cross Section - A graph or plot of ground elevation versus distance across a stream valley or a portion of it, usually along a line perpendicular to the stream or direction of flow.

DXF(file format) - The most widely-used interchange drawing format in the Computer Aided Design and Drafting (CADD) world.

Erosion - The group of processes whereby soil or rock material becomes loosened or dissolved and removed from any part of the earth's surface.

Flood - An overflow or inundation onto land areas not normally covered by water that are used or usable by people. Floods usually are characterized as temporarily inundating land areas which are adjacent to a body of water such as an ocean, lake, stream, or river.

Flood Crest - The maximum stage or elevation reached by the waters of a flood at any location.

Flood Plain - The relatively flat area of lowlands adjoining the channel of a river, stream, watercourse, ocean, lake, or other body of standing water that has been or may be covered by floodwater.

Flood Plain Management - The operation of a program intended to lessen the damaging effects of floods, maintain and enhance natural values, and make effective use of water and land resources within the flood plain. It is an attempt to balance values obtainable from use of flood plains with potential losses arising from such use. Flood plain management stresses consideration of a full range of the measures potentially useful in achieving its objectives.

Flood Plain Map - A map showing the areal extent of flooding.

Flood Profile - A graph that shows the relationship of water surface elevation to distance along the centerline of the channel. This report uses profiles to show the flood crest elevations of various floods.

Floodproofing - A combination of structural changes or adjustments to new or existing structures and facilities, their contents or their sites for the purpose of reducing or eliminating flood damages by protecting against structural failure, keeping water out, or reducing the effects of water entry.

Flood Warning - The issuance and dissemination of information about an imminent or current flood.

Floodway - That portion of the main stream channel plus any adjacent flood plain areas that must be kept free of encroachment in order that the 100-year flood can be carried without substantial increases in flood heights.

Floodway Fringe - That part of the flood plain that can be completely obstructed without increasing the 100-year flood level by more than 1.0 foot at any point.

Frequency - A statistical measure of how often a flood event of a given size or magnitude should, on the average, be equaled or exceeded.

Head - The height of water above any plane of reference.

Head Loss - The effect of obstructions, such as narrow bridge openings or buildings, that limit the cross-sectional area through which water must flow, raising the surface of the water upstream of the obstruction.

High Hazard Zone - An area, normally nearest the stream, where flooding may pose a significant risk to life and property. Areas having any one of the following conditions generally are considered high hazard:

- Areas where flood velocities exceed 5 feet per second (fps).

- Areas where flood depths are greater than 3 feet.

- Areas where the product of the velocity (in fps) and the depth (in feet) of the flood water exceeds seven.

Infiltration Rate - The rate at which water enters the soil at the surface and which is controlled by surface conditions.

Low Chord - The elevation at which a bridge girder first begins to reduce the cross-sectional flow area of the channel.

Low Hazard Zone - The area between the high hazard zone and the maximum extent of the 100-year frequency flood where the potential for loss of life and property damage is low.

Natural Values of Flood Plains - The desirable qualities of, or functions served by, flood plains including, but not limited to: water resources values (e.g. -- moderation of floods, water quality maintenance, and ground water recharge); living resource values (e.g. -- fish, wildlife, plant resources, and habitat); cultural resource values (e.g. -- open space, natural beauty, scientific study, outdoor education, and recreation); and cultivated resources values (e.g. -- agricultural, aquacultural, and forestry).

NGVD - National Geodetic Vertical Datum, formerly Mean Sea Level (MSL) 1929.

Nonstructural Measures - All flood plain management measures except structural flood control works. Examples of nonstructural measures are flood warning and preparedness systems, relocation, floodproofing, regulation, land acquisition, and public investment policy.

Recurrence Interval - The average time interval between actual occurrences of a hydrological event of a given or greater magnitude.

Relocation - Moving a building from a flood prone area by physically placing it on a vehicle and transporting it from the flood plain.

Return Period - See Recurrence Interval.

Road Overflow - The elevation of the point at which water first starts to flow over a road.

Station - Distance in feet along the centerline of the existing channel, increasing in an upstream direction.

Structural Measure - Flood control works such as dams and reservoirs, dikes and floodwalls, channel alterations, and diversion channels which are designed to keep water away from specific developments or populated areas, or to reduce flooding in such areas.

Transmission Rate - The rate at which the water moves in the soil and which is controlled by the soil horizons.

Wetland - An area where saturation with water is the dominant factor determining the nature of soil development and the types of plant and animal communities present; generally includes swamps, marshes, bogs, shallow lakes, and similar areas.

APPENDICES

A. FLOOD PROFILES

B. DISCHARGE and ELEVATION SUMMARY TABLES

C. FLOOD PLAIN MAPS

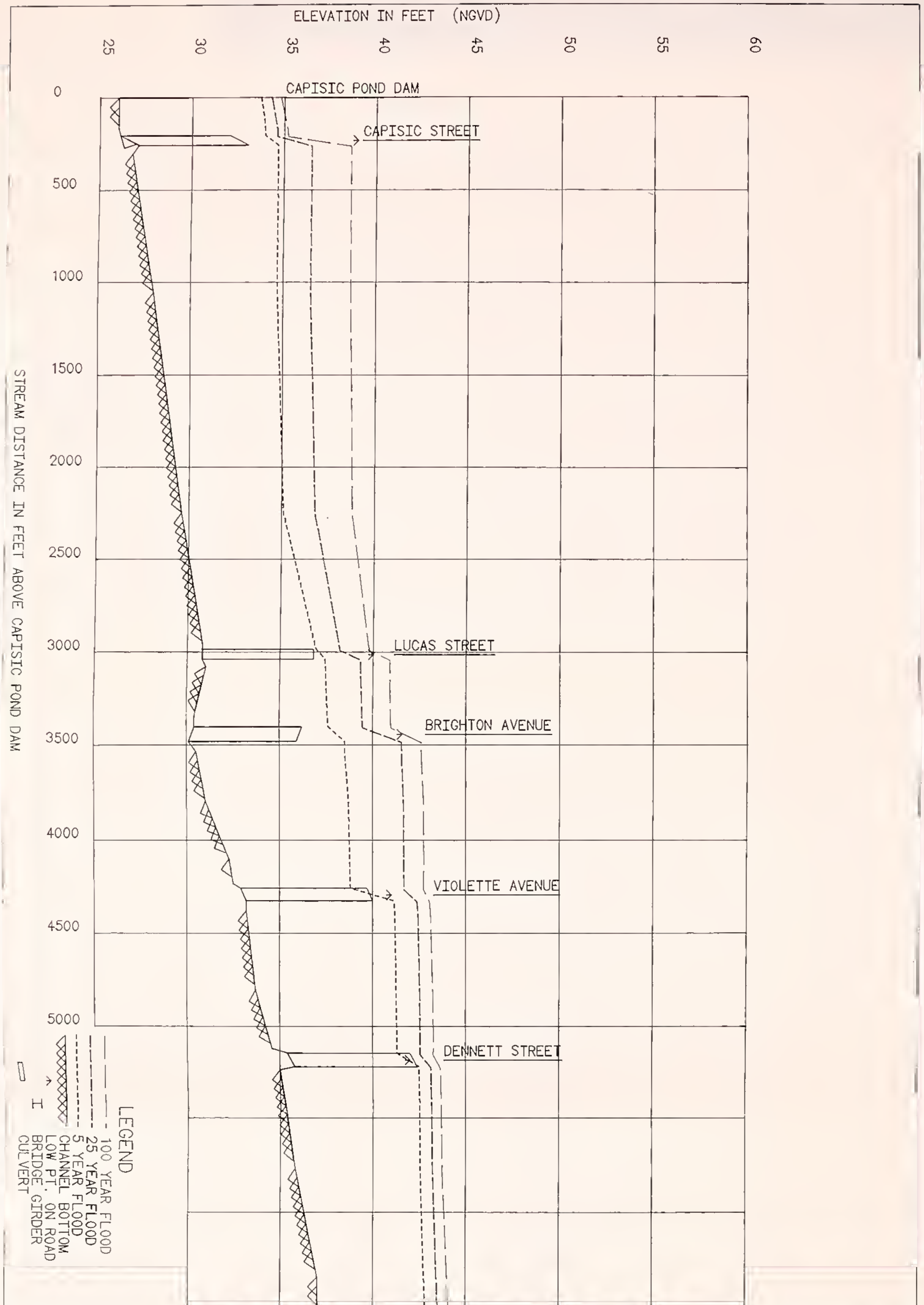
D. HYDROLOGIC SUMMARY TABLES (Separate Volumes)

   1. Flood Plain Analyses

   2. CSO Analyses

APPENDIX A

Flood Profiles



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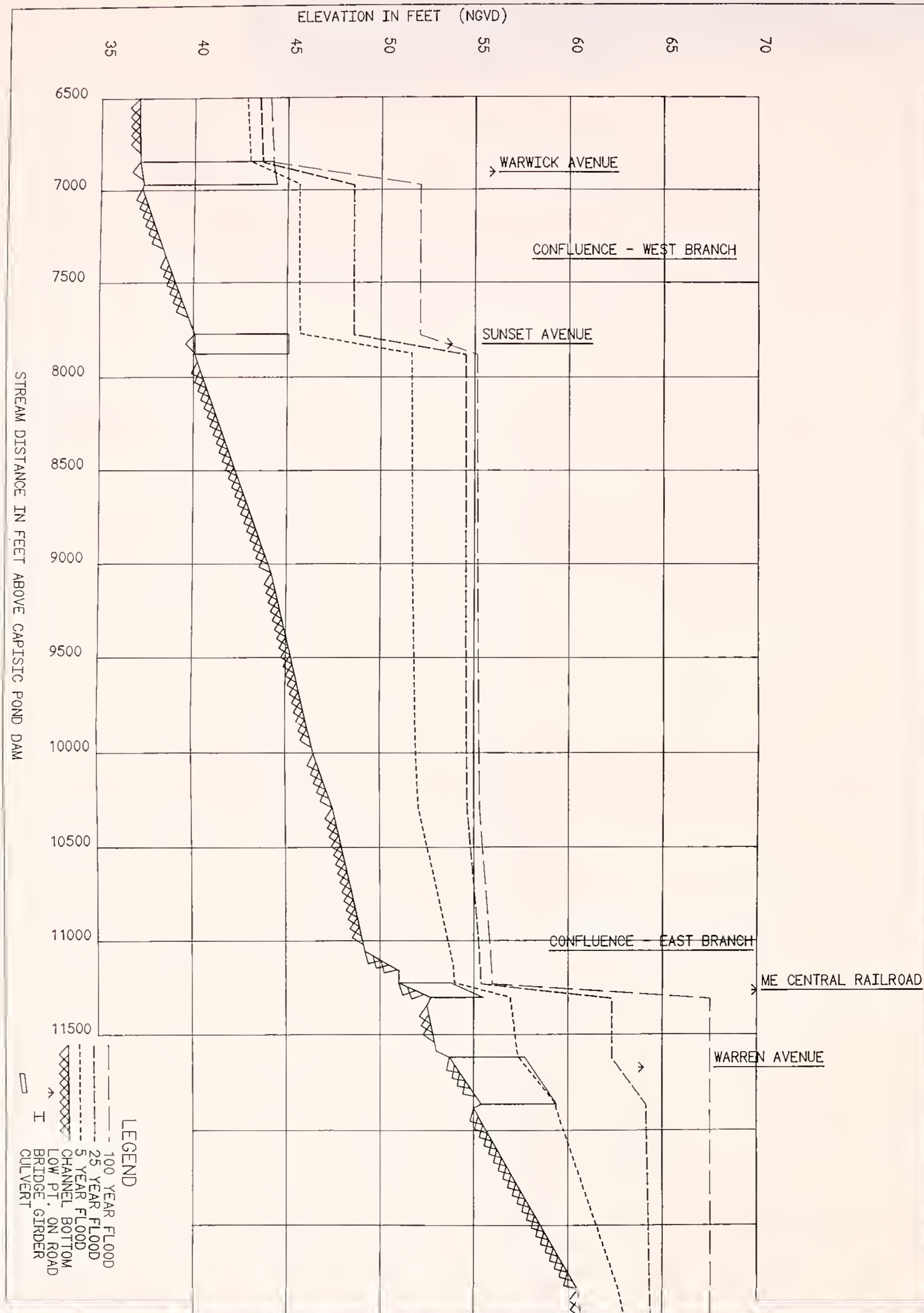
	CAPISIC BROOK WATERSHED PORTLAND, MAINE	CAPISIC BROOK



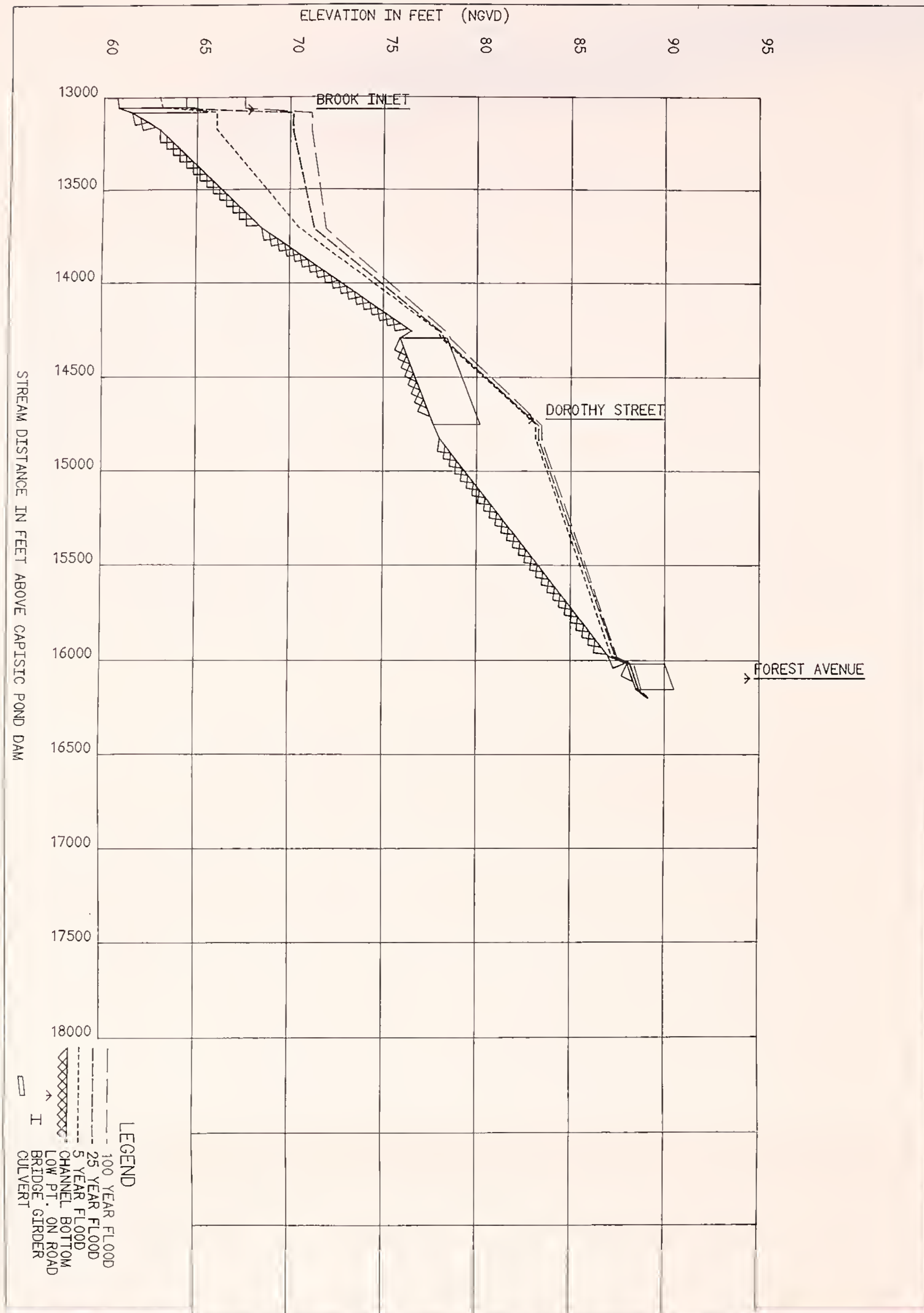
02P

U S DEPARTMENT OF AGRICULTURE
NATURAL RESOURCES CONSERVATION SERVICE

CAPISIC BROOK WATERSHED
PORTLAND, MAINE

FLOOD PROFILES

CAPISIC BROOK



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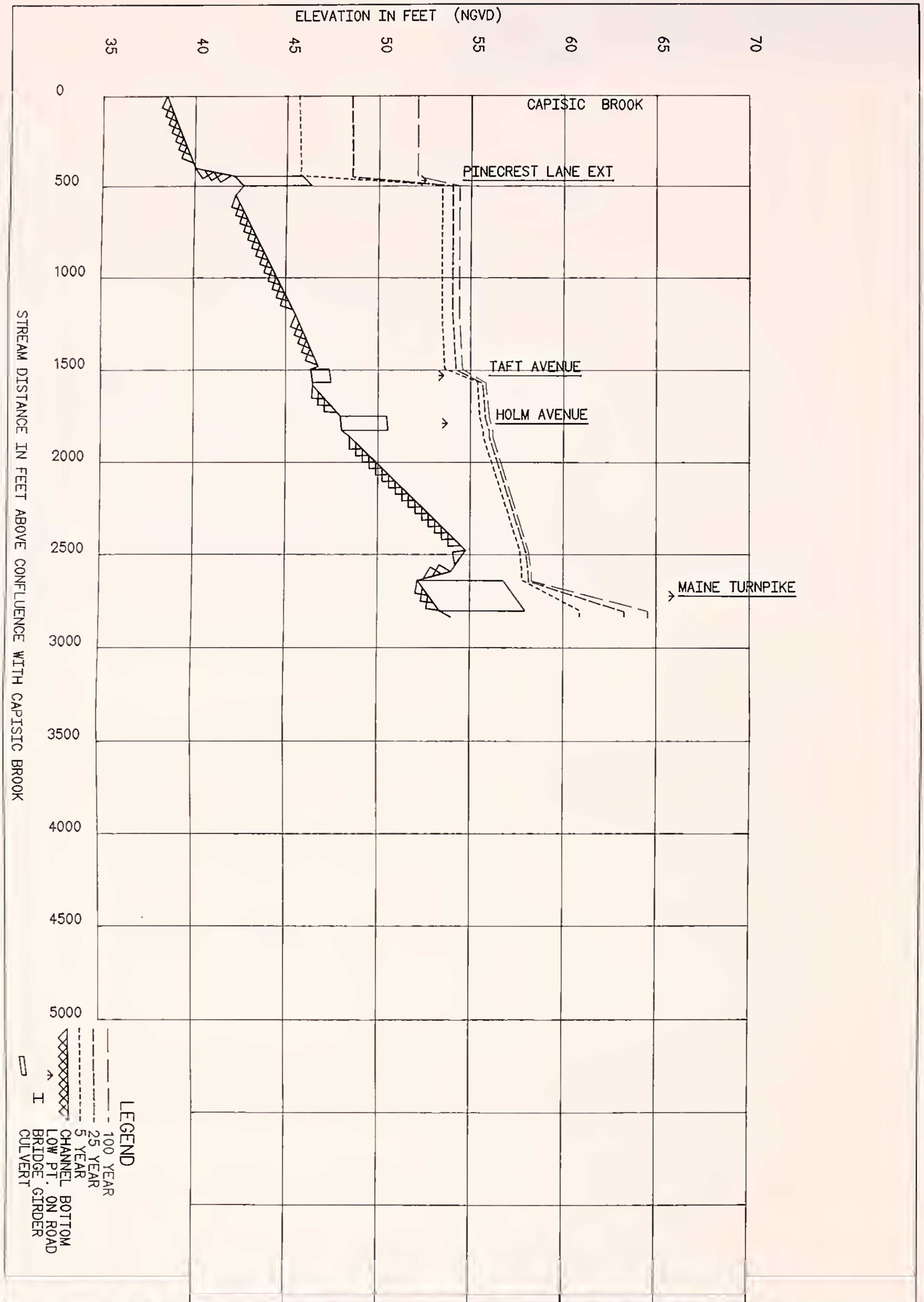


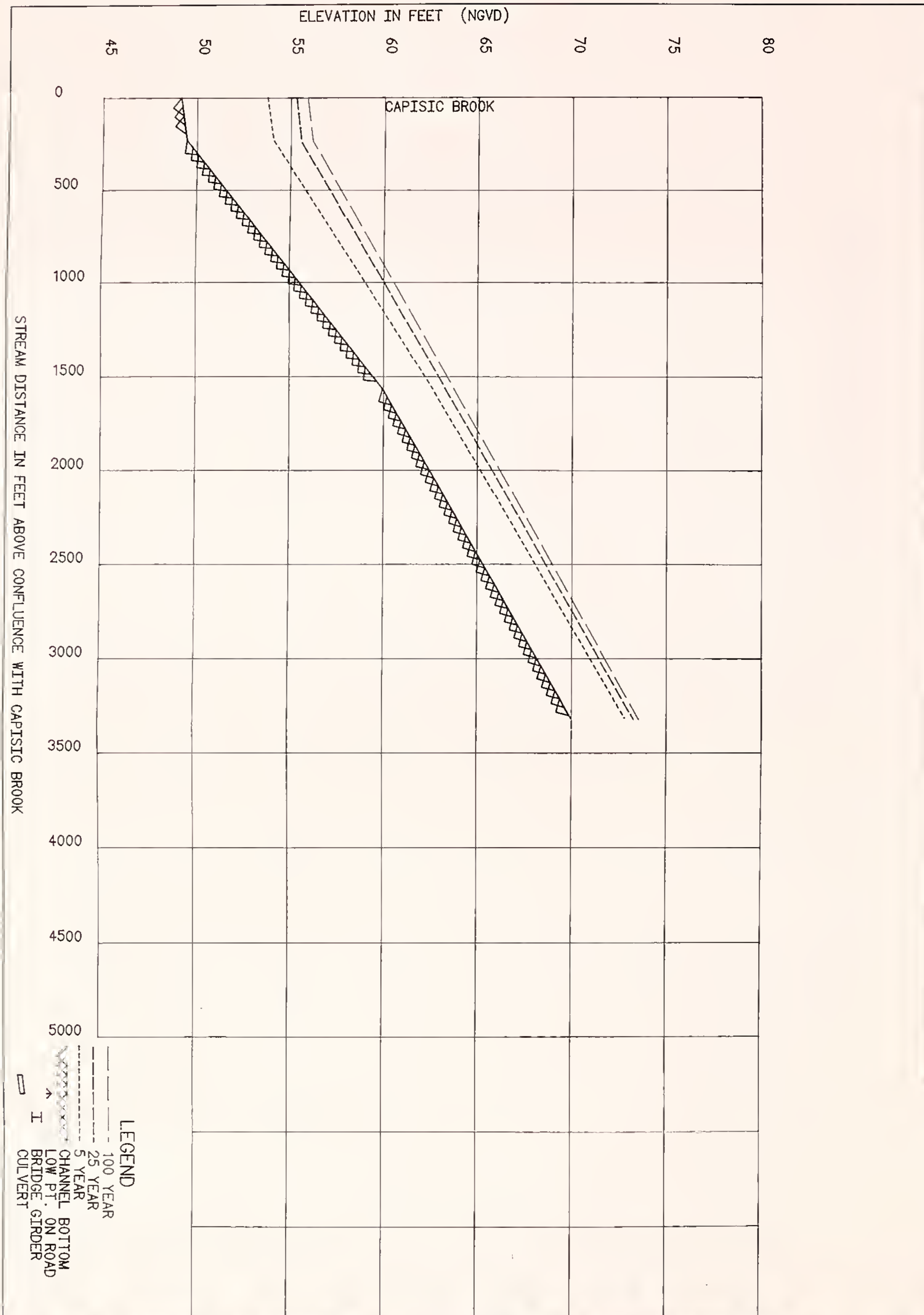
04P

U S DEPARTMENT OF AGRICULTURE
NATURAL RESOURCES CONSERVATION SERVICE

CAPISIC BROOK WATERSHED
PORTLAND, MAINE

FLOOD PROFILES

WEST BRANCH CAPISIC BROOK



05P	U S DEPARTMENT OF AGRICULTURE NATURAL RESOURCES CONSERVATION SERVICE CAPISIC BROOK WATERSHED PORTLAND, MAINE	FLOOD PROFILES EAST BRANCH CAPISIC BROOK

APPENDIX B

Discharge and Elevation Summary Tables

Table B1 - Capisic Brook Frequency - Discharge

Stream Location		Discharge in Cubic Feet per Second						
Name	Station	2 Year	5 Year	10 Year	25 Year	50 Year	100 Year	500 Year
Capisic Pond Dam	0	235	423	539	683	804	935	1337
Capisic Street	261	235	423	539	683	804	935	1337
CB21	309	235	423	539	683	804	935	1337
CB23	2250	281	444	561	729	886	1030	1430
CB24	2955	271	425	519	642	754	870	1121
Lucas Street	3041	271	425	519	642	754	870	1121
CB26	3080	271	425	519	642	754	870	1121
Brighton Avenue	3484	271	425	519	642	754	870	1121
CB31	3536	271	425	519	642	754	870	1121
CB34	4237	269	422	516	638	750	865	1114
Violette Avenue	4330	269	422	516	638	750	865	1114
CB36	4380	269	422	516	638	750	865	1114
CB38	4807	267	420	513	635	746	860	1108
CB39	5120	260	407	498	616	724	835	1075
Dennett Street	5221	260	407	498	616	724	835	1075
CB41	5239	260	407	498	616	724	835	1075
CB42	5768	308	470	547	655	743	835	1041
CB44	6800	304	464	540	647	734	825	1029
Warwick Avenue	6970	304	464	540	647	734	825	1029
CB46	6990	304	464	540	647	734	825	1029
CB47	7359	303	462	537	643	730	820	1023
CB49	7730	135	226	261	305	354	410	535
Sunset Lane	7879	135	226	261	305	354	410	535
CB51	7918	135	226	261	305	354	410	535
CB52	9050	147	245	283	331	384	445	581
CB53	10007	131	235	296	374	431	490	647
CB54	11055	143	257	323	408	471	535	707
CB59	11162	38	60	74	94	108	120	150
Railroad	11303	38	60	74	94	108	120	150
CB61	11347	38	60	74	94	108	120	150
CB64	11585	34	56	68	74	81	90	106
Warren Avenue	11864	34	56	68	74	81	90	106
CB66	11884	34	56	68	74	81	90	106
CB68	12842	32	53	65	70	77	85	100
Brook Inlet	13083	33	67	77	91	119	145	203
CB73	13709	25	51	58	69	91	110	154
CB74	14257	17	35	40	47	62	75	105
Dorothy Street	14753	17	35	40	47	62	75	105
Forest Avenue	16153	0	0	1	1	1	1	1

Table B2 - West Branch Frequency - Discharge

Stream Location		Discharge in Cubic Feet per Second						
Name	**Station**	**2 Year**	**5 Year**	**10 Year**	**25 Year**	**50 Year**	**100 Year**	**500 Year**
WB4	402	193	280	340	403	447	485	601
Sewer Line	498	193	280	340	403	447	485	601
WB6	551	193	280	340	403	447	485	601
WB8	1200	185	282	338	394	431	460	566
WB9	1480	185	282	338	394	431	460	566
Taft Avenue	1569	185	282	338	394	431	460	566
WB11	1583	185	282	338	394	431	460	566
WB14	1738	174	263	312	360	389	410	501
Holm Avenue	1829	174	263	312	360	389	410	501
WB16	1860	174	263	312	360	389	410	501
WB18	2479	173	254	298	337	360	375	452
WB19	2594	146	211	244	273	290	300	363
Maine Turnpike	2804	146	211	244	273	290	300	363
WB21S	2836	146	211	244	273	290	300	363

Table B3 - East Branch Frequency - Discharge

Stream Location		Discharge in Cubic Feet per Second						
Name	**Station**	**2 Year**	**5 Year**	**10 Year**	**25 Year**	**50 Year**	**100 Year**	**500 Year**
EB2	230	71	135	191	262	315	370	521
EB4	1565	60	115	163	223	268	315	444
EB6	3315	32	63	86	113	134	155	208

Table B4 - Capisic Brook Frequency - Elevation

Stream Location		Elevation in Feet (NGVD)						
Name	Station	2 Year	5 Year	10 Year	25 Year	50 Year	100 Year	500 Year
Capisic Pond Dam	0	33.20	33.75	34.00	34.33	34.57	34.82	35.50
Capisic Street	261	33.60	34.69	35.39	36.50	37.44	38.62	40.13
CB21	309	33.60	34.69	35.39	36.50	37.44	38.62	40.13
CB23	2250	34.07	35.12	35.78	36.80	37.69	38.80	40.31
CB24	2955	35.85	36.87	37.34	38.15	38.87	39.72	41.04
Lucas Street	3041	36.11	37.43	38.15	39.34	40.36	40.88	41.54
CB26	3080	36.13	37.45	38.16	39.35	40.36	40.89	41.55
Brighton Avenue	3484	36.71	38.51	39.67	41.56	42.30	42.58	42.98
CB31	3536	36.72	38.52	39.68	41.56	42.30	42.58	42.97
CB34	4237	37.31	38.81	39.88	41.68	42.42	42.71	43.15
Violette Avenue	4330	38.93	41.16	41.74	42.39	42.80	43.04	43.48
CB36	4380	39.02	41.20	41.78	42.43	42.83	43.09	43.53
CB38	4807	39.15	41.29	41.88	42.53	42.95	43.21	43.70
CB39	5120	39.27	41.33	41.92	42.56	42.97	43.25	43.73
Dennett Street	5221	41.04	42.51	42.80	43.13	43.40	43.61	44.04
CB41	5239	41.05	42.52	42.81	43.14	43.42	43.63	44.07
CB42	5768	41.11	42.56	42.87	43.21	43.50	43.72	44.19
CB44	6800	41.83	42.99	43.30	43.65	43.95	44.19	44.70
Warwick Avenue	6970	43.45	45.63	46.69	48.54	50.18	52.05	56.23
CB46	6990	43.46	45.64	46.69	48.54	50.18	52.05	56.23
CB47	7359	43.53	45.66	46.71	48.55	50.19	52.06	56.23
CB49	7730	43.65	45.70	46.73	48.56	50.19	52.06	56.23
Sunset Lane	7879	46.49	51.67	54.08	54.53	54.83	55.12	56.45
CB51	7918	46.49	51.67	54.08	54.53	54.83	55.12	56.45
CB52	9050	47.72	51.73	54.10	54.55	54.86	55.16	56.49
CB53	10007	49.39	51.93	54.16	54.63	54.95	55.25	56.58
CB54	11055	52.54	53.75	54.92	55.31	55.60	55.87	56.99
CB59	11162	52.90	53.95	55.00	55.39	55.67	55.94	57.04
Railroad	11303	55.56	56.93	59.33	62.32	64.97	67.50	70.03
CB61	11347	55.74	57.00	59.34	62.33	64.98	67.50	70.03
CB64	11585	56.32	57.31	59.38	62.33	64.98	67.50	70.03
Warren Avenue	11864	58.04	59.38	61.72	64.16	65.02	67.52	70.05
CB66	11884	58.06	59.38	61.72	64.16	65.02	67.52	70.05
CB68	12842	62.27	62.68	63.09	64.35	65.11	67.53	70.05
Brook Inlet	13083	63.92	66.06	68.40	70.15	70.67	71.14	72.21
CB73	13709	69.92	70.51	70.74	71.35	71.61	71.94	72.73
CB74	14257	77.66	77.95	78.02	78.09	78.25	78.37	78.70
Dorothy Street	14753	79.73	83.13	83.21	83.28	83.38	83.43	83.53
Forest Avenue	16153	88.57	88.62	88.64	88.67	88.71	88.76	88.76

Table B5 - West Branch Frequency - Elevation

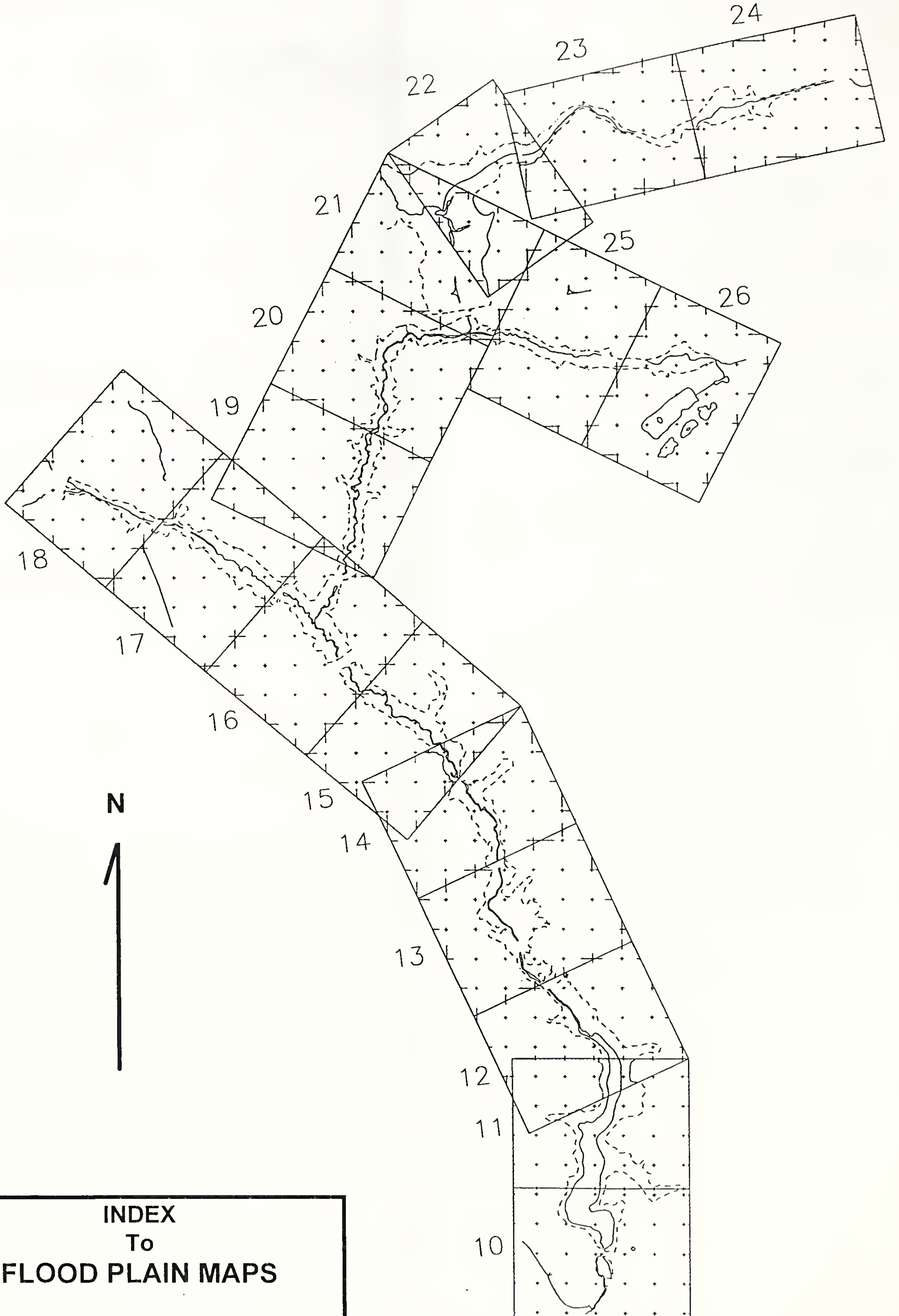
Stream Location		Elevation in Feet (NGVD)						
Name	**Station**	**2 Year**	**5 Year**	**10 Year**	**25 Year**	**50 Year**	**100 Year**	**500 Year**
WB4	402	43.98	45.78	46.78	48.58	50.20	52.07	56.23
Sewer Line	498	51.47	53.44	53.75	54.02	54.18	54.34	56.37
WB6	551	51.48	53.44	53.75	54.02	54.18	54.34	56.38
WB8	1200	51.50	53.45	53.77	54.04	54.20	54.36	56.39
WB9	1480	51.79	53.59	53.91	54.20	54.36	54.52	56.45
Taft Avenue	1569	55.11	55.39	55.53	55.64	55.72	55.79	56.72
WB11	1583	55.11	55.39	55.53	55.65	55.73	55.79	56.73
WB14	1738	55.16	55.49	55.65	55.78	55.87	55.95	56.83
Holm Avenue	1829	55.33	55.68	55.86	56.02	56.11	56.17	56.96
WB16	1860	55.33	55.69	55.87	56.02	56.11	56.17	56.97
WB18	2479	57.27	57.65	57.79	57.98	58.10	58.11	58.44
WB19	2594	57.37	57.78	57.94	58.13	58.25	58.25	58.60
Maine Turnpike	2804	58.83	60.89	62.08	63.29	64.05	64.52	66.08
WB21S	2836	58.83	60.89	62.08	63.29	64.05	64.52	66.08

Table B6 - East Branch Frequency - Elevation

Stream Location		Elevation in Feet (NGVD)						
Name	**Station**	**2 Year**	**5 Year**	**10 Year**	**25 Year**	**50 Year**	**100 Year**	**500 Year**
EB2	230	52.92	54.10	55.12	55.55	55.85	56.13	57.20
EB4	1565	62.11	62.62	62.93	63.33	63.46	63.73	64.27
EB6	3315	72.33	72.79	73.04	73.25	73.24	73.48	73.75

APPENDIX C

Flood Plain Maps



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HORIZONTAL DATUM – MAINE STATE PLANE COORDINATE SYSTEM (WEST ZONE) 500' GRID

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FROM AERIAL PHOTOGRAPHS DATED 5–15–92

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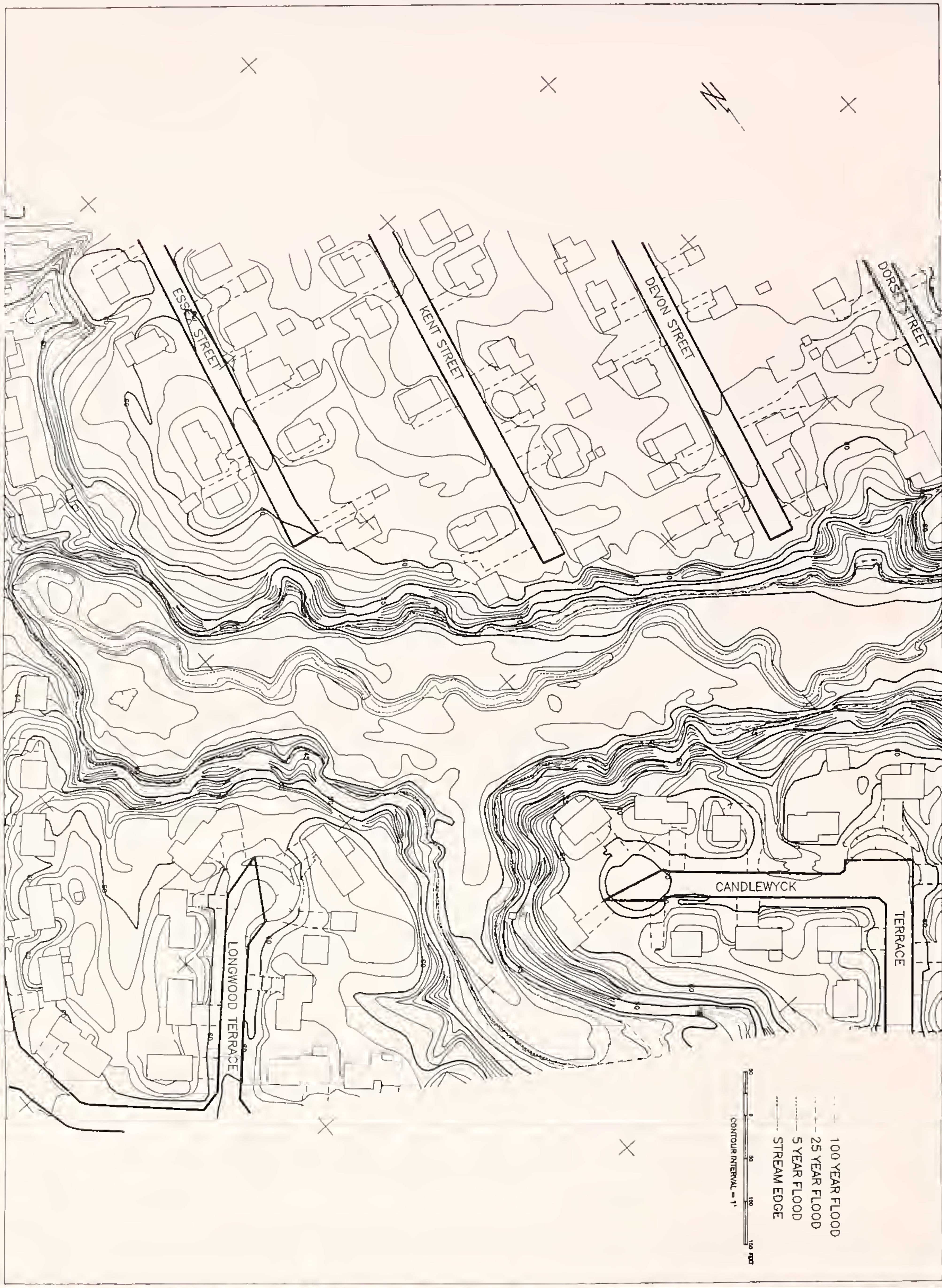

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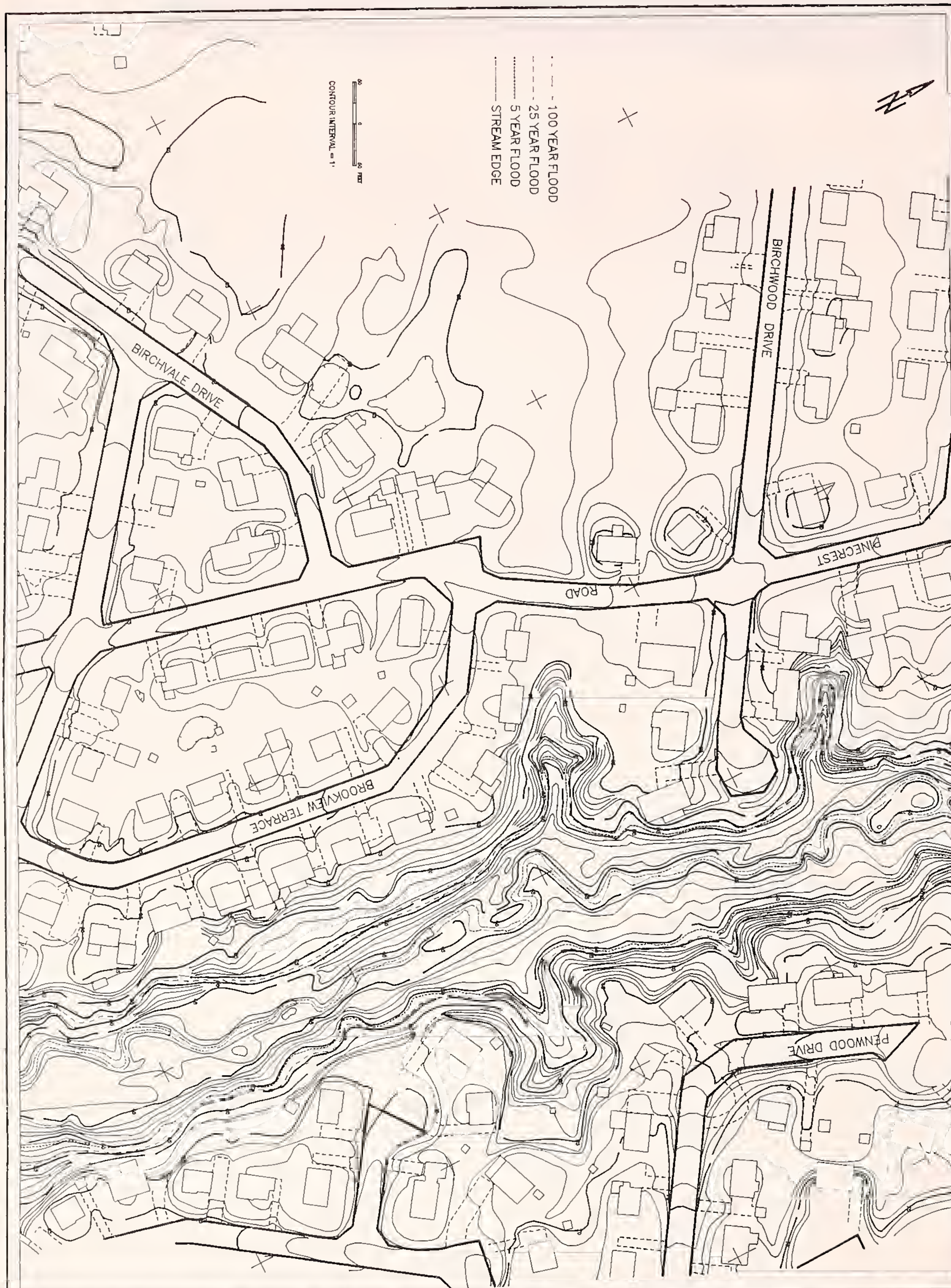

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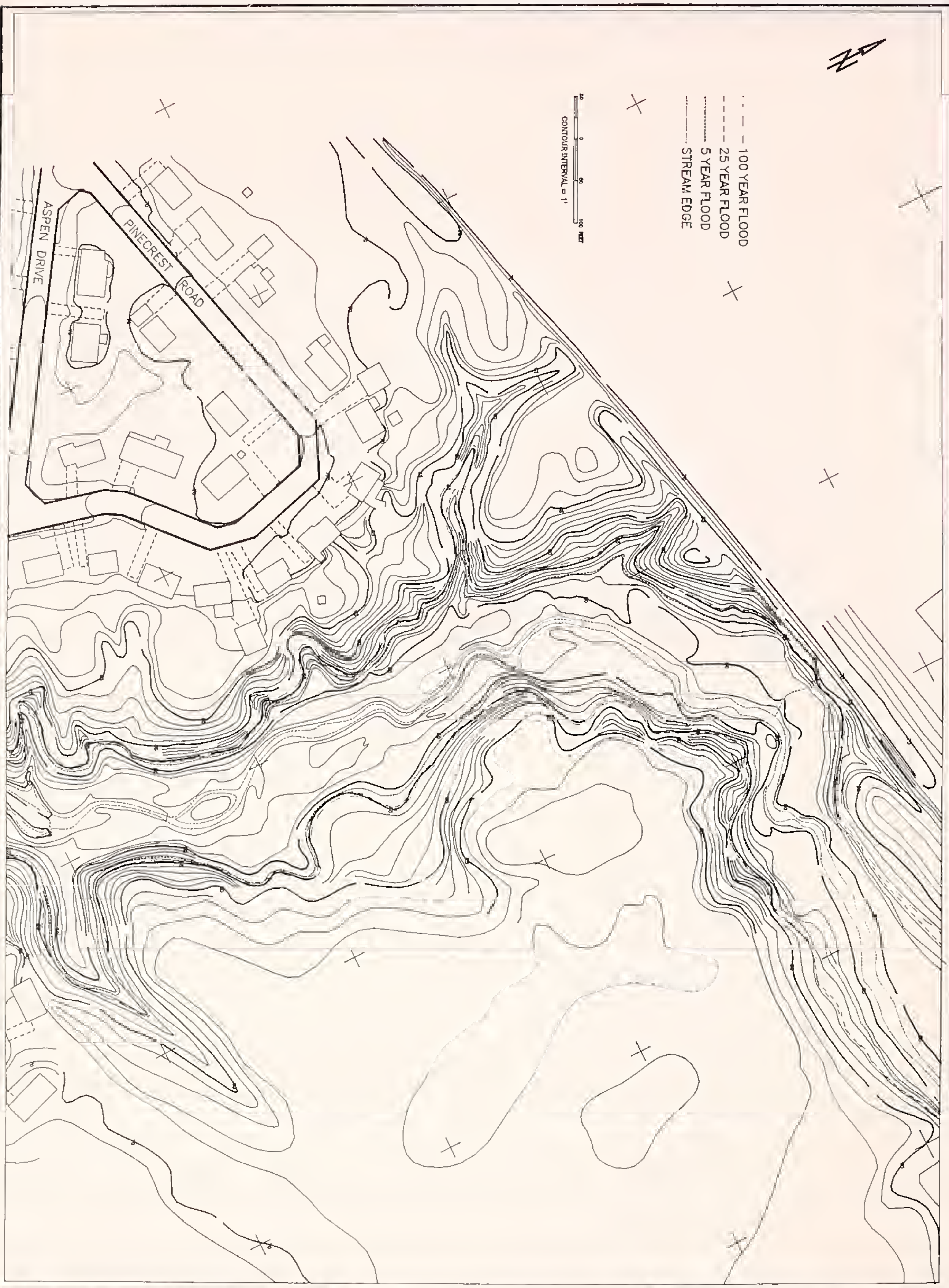

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FROM AERIAL PHOTOGRAPHS DATED 5–15–92

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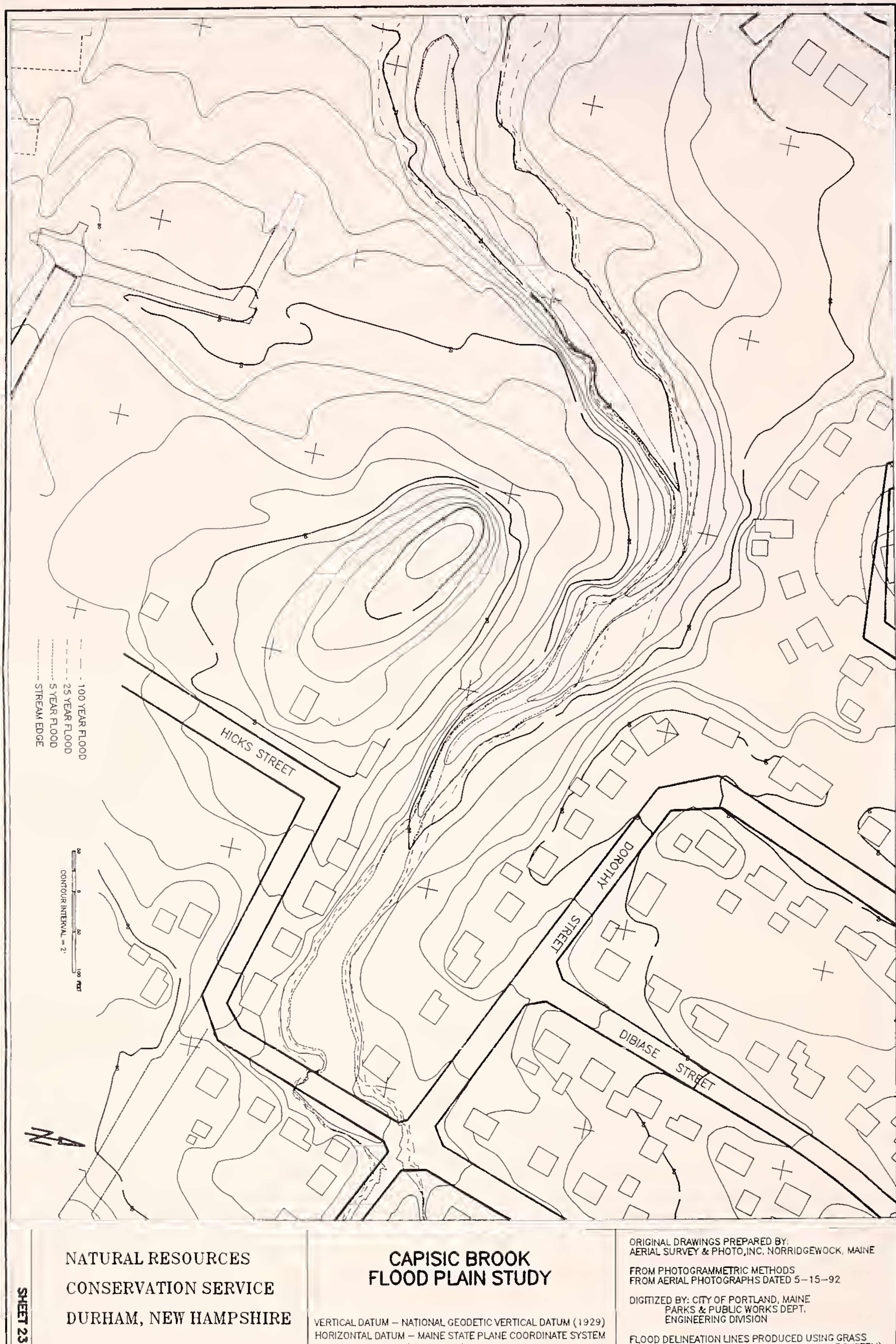
FLOOD DELINEATION LINES PRODUCED USING GRASS (GEOGRAPHIC RESOURCE ANALYSIS SUPPORT SYSTEM) BY THE NATURAL RESOURCES CONSERVATION SERVICE, DURHAM, NEW HAMPSHIRE



SHEET 23

NATURAL RESOURCES
CONSERVATION SERVICE
DURHAM, NEW HAMPSHIRE

FEBRUARY, 1995

CAPISIC BROOK FLOOD PLAIN STUDY

VERTICAL DATUM – NATIONAL GEODETIC VERTICAL DATUM (1929)
HORIZONTAL DATUM – MAINE STATE PLANE COORDINATE SYSTEM (WEST ZONE) 500' GRID

ORIGINAL DRAWINGS PREPARED BY:
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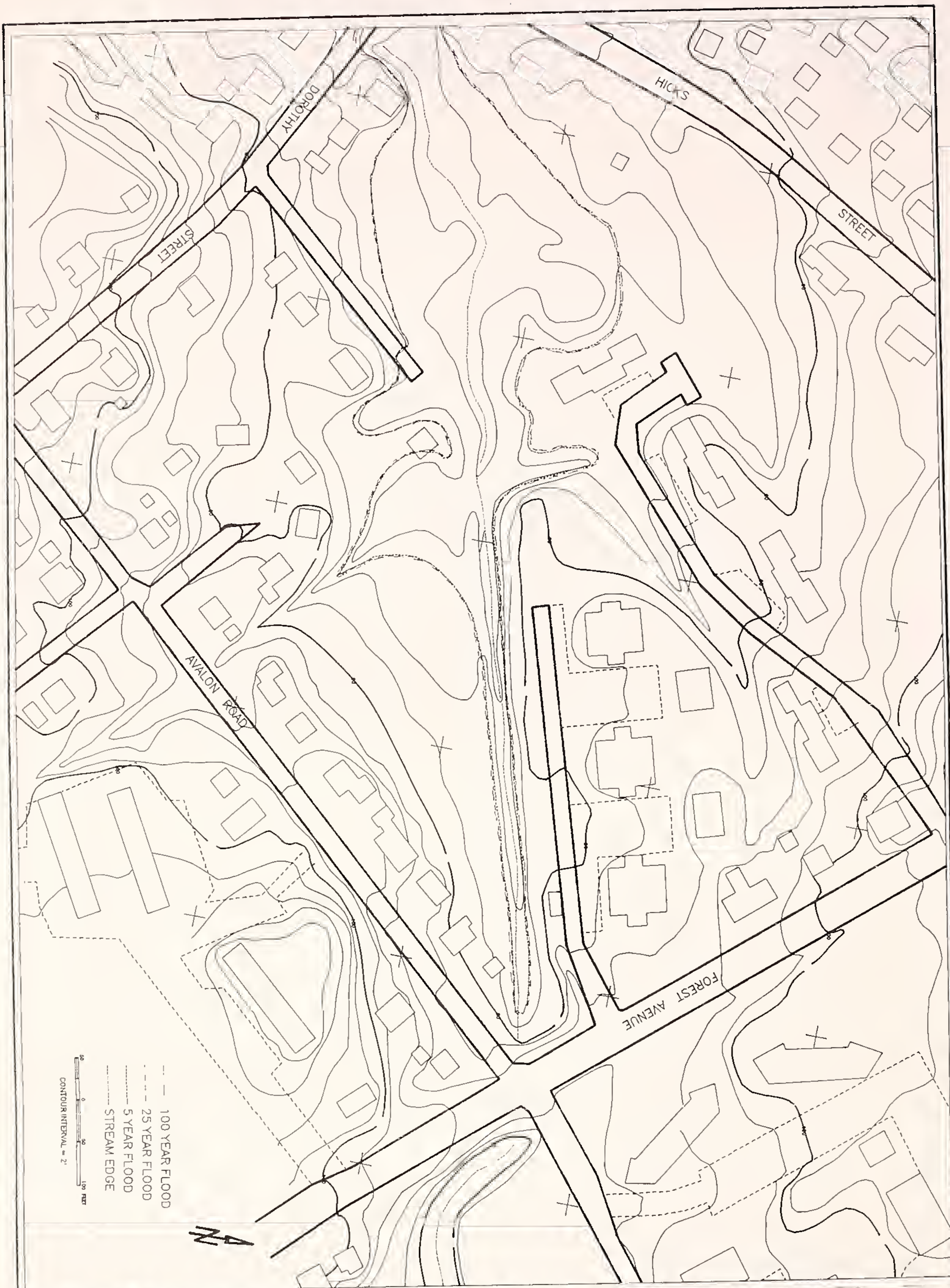

SHEET 24

NATURAL RESOURCES
CONSERVATION SERVICE
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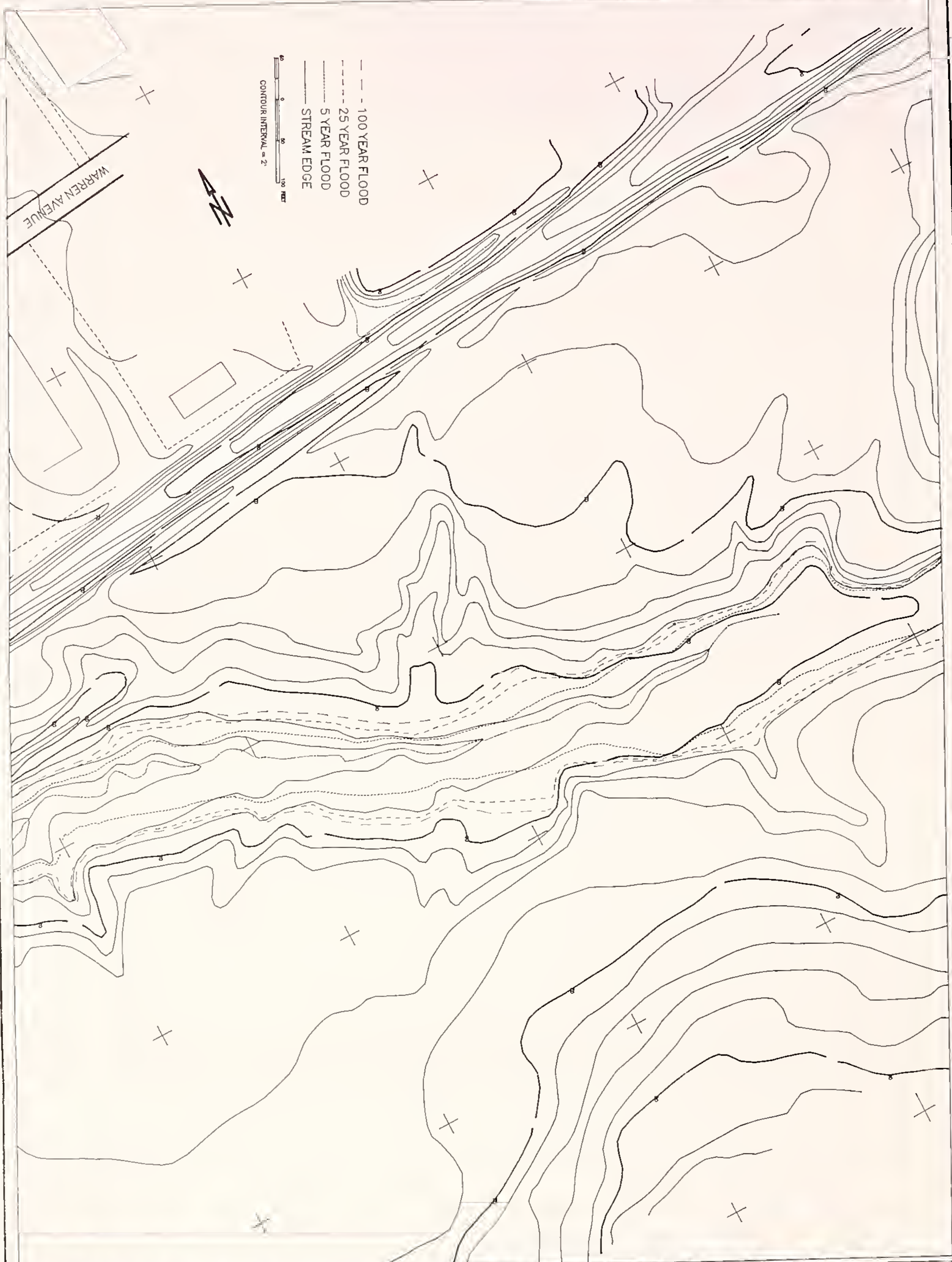

SHEET 25

NATURAL RESOURCES CONSERVATION SERVICE
DURHAM, NEW HAMPSHIRE

JANUARY, 1995

CAPISIC BROOK FLOOD PLAIN STUDY

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SHEET 26

NATURAL RESOURCES
CONSERVATION SERVICE
DURHAM, NEW HAMPSHIRE

JANUARY, 1995

CAPISIC BROOK
FLOOD PLAIN STUDY

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